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This Journal *is non-political and seeks only to further the pursuit of knowledge. The main purpose is to communicate to scholars abroad the results of scientific investigations of the Orient as carried out in Israel. But as fruitful work can be accomplished only by reciprocal endeavour, papers from contributors in other countries will be gladly considered. The subjects to be dealt with include: the history, archaeology and culture of the countries of the Middle East, as well as their geography and natural features.—The Editors are not responsible for the opinions expressed by contributors.*

A New Neolithic Industry: The Yarmukian of Palestine*

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A PICTURE of prehistoric life in Palestine is presented by a newly discovered village near Sha'ar ha-Golan in the Jordan Valley. This village was situated in the Ghor, on the banks of the Yarmuk River. It was well watered and its fertile surroundings appealed to the prehistoric cultivators, shepherds, fishermen and hunters. The River Yarmuk, too, was an important factor in the social progress of this community.

The finds include artifacts of flint, stone and bone, as well as stone carvings and pottery. The hillsides sloping down to the Yarmuk are strewn with cairns, stone circles and cup-marks which may yield additional valuable material but these have not yet been explored on account of the war.

In the year 1943 a short archaeological survey, which covered a part of the triangle formed by the Rivers Yarmuk and Jordan and the Sea of Galilee, was undertaken by Messrs. B. Maisler, S. Yeivin and myself on behalf of the Ancient East Research Association.[1] It was during this tour that the prehistoric remains in the Yarmuk River region first came to my knowledge.

I visited the site and picked up some potsherds, animal bones and flint implements from an exposed layer of grey earth on the bank of the river near the settlement of Sha'ar ha-Golan. The finds were in their stratigraphic position.

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* This article is the translation of a paper published in Hebrew in *Eretz-Israel*, the Annual of the Jewish Palestine Exploration Society, Vol. 1.

[1] Maisler, B. & Yeivin, S.: Provisional report on an Exploration of the Northern Jordan Valley. Stekelis, M.: On the Prehistoric Stations in the Jordan Valley. *Bull. Jew. Palest. Explor. Soc.*, 10, 1943, pp. 98-104.

The whole area was further explored by the geologist Dr. P. Solomonica and myself, and a report on the many interesting archaeological discoveries and geological observations will soon be published.

Additional finds and stratigraphical observations were subsequently made in an anti-tank trench dug by the British Army in the fields nearby. This trench was approximately one km. long, and in some sections of it gravel and the remains of stone walls could be seen.

Investigation revealed that a level of grey earth, covering the gravel in the trench section yielded flint implements of the same type as those discovered in the exposed section on the bank of the River Yarmuk.

THE SITE

The prehistoric village lies SSE of the kibbutz (co-operative settlement) of Sha'ar ha-Golan, covering some thousands of square metres of the kibbutz land which slopes down to the line of an old river bank 12 m. above the River Yarmuk (see map, Fig. 1). The alluvial soil is black, and stone foundations and scattered fragments of pottery belonging to the Early Bronze IV Period are to be seen on the surface.

The remains of the prehistoric settlement were discovered under the Early Bronze IV layer in a layer of grey earth; a sterile layer of black earth approximately 0.25 m. thick separated it from the Early Bronze layer. In the course of digging a fishpond, approximately 600 square metres of beach earth was removed and a layer of grey earth which yielded prehistoric finds was exposed. This layer had not been disturbed by deep ploughing, and the finds from it are sufficiently varied to give an idea of the prehistoric settlement and its material culture.

STRATIGRAPHY

The stratigraphy of the site as revealed by soundings and exploration is as follows:

A. 0—0.70 m. Black earth. Stone foundations of rectangular houses built of unhewn stones. Pottery of Early Bronze Age IV was discovered near the foundations.

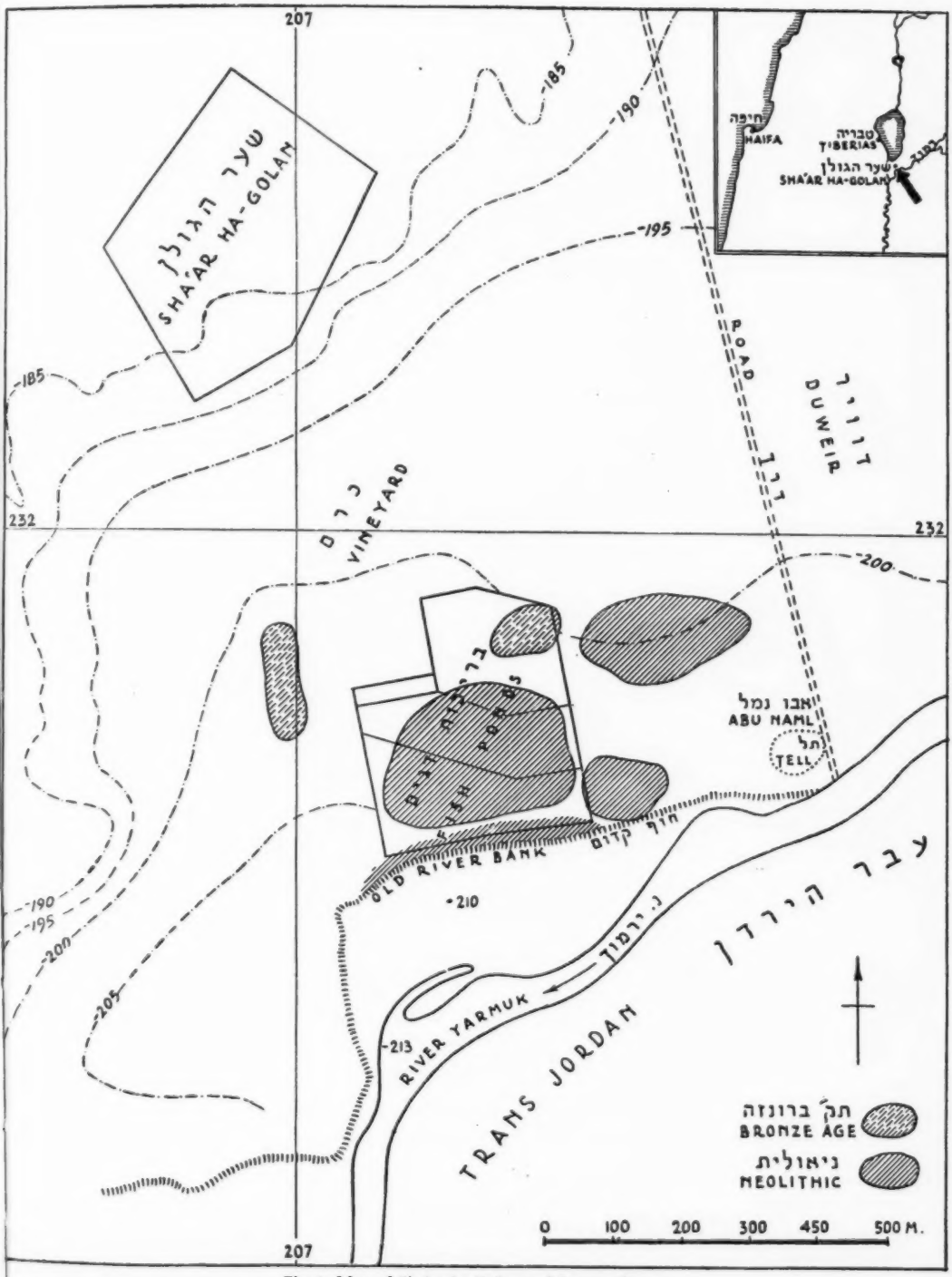

Fig. 1. Map of Sha'ar ha-Golan and Surroundings.

B. 0.70—1.10 m. Black earth. This layer was found below the stone foundations; it was further found in the anti-tank trench and in the exposed section of the river bank. It produced no antiquities.

C. 1.10—2.20 m. Grey earth with angular stones and some rolled pebbles. This layer is rich in flint implements and animal bones; *Sus scrofa, Gazella* sp., *Equus* sp., *Bos* sp., *Camelus* sp. In many places fragments of crude hand-made pottery was picked up together with flint tools. It is this layer which yielded the remarkable finds described in this paper.

D. 2.20— . . . A gravel-bed composed of basalt and flint pebbles was found directly under the layer of grey earth (C). Its depth is not yet known as only 0.70 m. have been dug. Cores and flakes of Palaeolithic technique were picked up from the top of this gravel-bed.

MATERIAL CULTURE

RAW MATERIAL. The people on this site depended for their raw material on rock found nearby. They used grey chert, black and chocolate-brown flint, chalcedony, quartzite, limestone, basalt, sandstone and clay—partly found in the Yarmuk gravels and partly in the chalk deposits on the hills. Chert, chalcedony and flint were used for making all kinds of implements. Basalt was used for making pestles, mortars, mace-heads, spindle-whorls, querns and cups. Limestone and sandstone were used for pendants, spindle-whorls, cups and whetstones. Clay, combined with local material for tempering, was used for pottery. Some artifacts were made from bones of animals which the inhabitants had killed. Thousands of flint, basalt and limestone chips prove that tools were locally made.

FLINT IMPLEMENTS.—*Technique:* All flint implements have been flaked with wooden mallets. The debris of their manufacture is quite fresh, except for a number of smooth pieces showing traces of patina which were picked up on the surface. A number of implements show the influence of fire. Agricultural implements, as for example celts, hoes, axes and chisels were made in addition to arrow-heads and axes for hunting. The core implements which range from small to heavy and crude forms, were chipped on both surfaces. The well-finished tools, more or less sym-

metrical in form and in sections, are sharpened all round with a straight, concave, or ellipsoid cutting edge and with a pointed butt end.

Axes and Celts: Figures 2 and 3 show varieties of these types. There are two kinds of tools, one with a polished cutting edge, the other without. Both of them are flaked on both sides with large flakes; the edges are sharp all around. The polished cutting edge was made by rubbing on both sides; sometimes the arêtes were also rubbed down.

Figure 2 shows axes and celts with polished cutting edges. (The polished surfaces are shown in black.) A large flint axe 18 cm. long (Fig. 2, No. 1), ellipsoid in cross-section, is flaked on both surfaces with large flakes. The edges are sharpened by secondary trimming. The cutting edge is ellipsoid and very well polished on both surfaces. The outline of tool No. 11 is triangular with a convex polished cutting edge. Nos. 6 and 10 are diminutive flint axes, of similar shape; they are 5 cm. and 4.5 cm. long respectively, and well-polished with more or less straight cutting edges. No. 7 is a small axe, with fairly parallel sides and polished convex cutting edge. Usually only one cutting edge of the axes was polished at one end, but No. 4 had its two cutting edges polished. It may be asked whether this specimen can be considered as a prototype of a votive 'double-axe'. The celts are of different sizes and some of them are flatter on one side. The polished cutting edges are either ellipsoid (Nos. 2, 13) or convex (Nos. 3, 5, 8, 12, 14-16).

Figure 3 comprises some types with unpolished cutting edges. Nos. 1, 5, 8 and 11 are axes flaked on both surfaces with large flakes and very sharp edges. Nos. 2 and 7 are axes with double-pointed arch-ends. These peculiar types of implements can be compared with the double-ended polished axe (cf. Fig. 2, No. 4).

Tranchets: There are five specimens which can be considered as tranchets, as their cutting edge was formed by a transversally struck blow (Fig. 3, Nos. 9-11).

Pick-Axes: This special type of pointed implements made of flint pebbles with crusted butt seems to be characteristic of this culture. Both faces have been flaked, the edges sharp and straight. The pick-axes resemble the

well-known Asturian picks from Northern Spain (Fig. 3, Nos. 4 and 6). No. 3 shows a variety of the same type without crusted butt. Another variety of the same type is a thick pointed flake with an oblique striking platform with the upper face struck with large flakes.

Probably, the celts, axes and hatchets were mounted on shafts, but there are no indications of the method of shafting adopted.

Cores: Most of the cores were flint pebbles of different sizes from the river. Many of them had one or two striking platforms and a secondary trimming of the flaking edge, and could thus be used as scrapers.

Fig. 4, No. 1 is a long core with a double striking platform of light grey impure flint, a large flake having been struck off. No. 2 is a core with double striking platform with secondary trimming on the flaking edges, probably used as a scraper. No. 3 is a tortoise-like core with crusted back left untrimmed: a large pointed flake has been struck off. No. 4 is a core with a single striking-platform: small, long flakes have been struck off. There is in addition a small group of neatly made cores, such as one usually associated with Mesolithic industry. These small cores have either single or double striking platforms and many of them have been used as core scrapers. Typical specimens are shown in Fig. 4, Nos. 9-13. Nearly all the cores were used as scrapers as well and were trimmed for this purpose.

Blades, Flakes and Knives: The numerous blades and flakes have unsymmetrical outlines and are of different sizes, some of them retaining the natural crust of the flint. A considerable number of them were certainly used for cutting, serrating, sawing or scraping. Blades and flakes with 'inverse retouche' along one or both lateral edges as well as a large number of narrow blades without lateral retouche are common. Many blades and flakes show traces of wear along the sharp edges.

Elongated symmetrical blades, probably used as knives (Fig. 5, Nos. 1, 4, 11). Blades with 'inverse retouche' (Fig. 5, Nos. 2 and 7). Pointed blade with retouche on both lateral edges and with 'inverse retouche' along both of its edges (No. 3). Large blade with retouche on one lateral edge and with 'inverse retouche' (No. 5). Rough curved flake with a part of the cortex on the base retouched with large flakes on one lateral edge and with

'inverse retouche' near the top (No. 8). Elongated thick rough flake with one 'serrated' lateral edge inversely retouched; on top some 'burning-like' chips (No. 9); two pointed blades with very little retouche on both lateral edges were probably used as knife blades (Fig. 5, Nos. 10, 11).

Beautifully curved pointed blade; one face well trimmed by pressure flaking near the top; inversely retouched on one lateral edge (No. 12). No. 13 is a *'Chatelperron'* point; Nos. 14-16 are knife blades, No. 14 is a broken specimen of a long blade and was retouched on the bulbar surface by pressure flaking; No. 15 is made of tabular flint, both faces covered with cortex, one working edge was retouched by regular pressure flaking on both faces; No. 16 is a knife retouched on the bulbar surface by irregular pressure flaking. Concave-convex blade retouched on both edges by pressure flaking (No. 6) was probably used as a scraper.

Arrow-Heads and Spearheads: Fig. 6, Nos. 1-4, 6-8; Fig. 7, Nos. 13-18, 22, 25, 26, 30.

The following types were found: Leaf-shaped pressure flaked on both faces (Fig. 6, No. 2; Fig. 7, No. 15); leaf-shaped and retouched all over (Fig. 6, Nos. 6, 8; Fig. 7, No. 17); tanged—the tang was retouched on one or both faces (Fig. 6, Nos. 1, 3, 4, 7; Fig. 7, Nos. 16, 17, 18, 28, 31, 32), or pressure flaked on both faces (Fig. 7, Nos. 13, 14).

Sickle-Blades: The square type with rows of unilateral or bilateral teeth is most frequent; some of the sickle-blades are bifacially flaked by pressure flaking technique. Some sickle-blades show friction gloss on one of their lateral edges; they have probably been used in cutting grass containing silica (Fig. 7, No. 29).

Hammer-Stones: Spherical flint pebbles were used as hammer-stones.

Awls: Awls on coarse flakes with thick, strong working point, are represented. These implements were used for perforating stone pendants, stone whorls and mace-heads (Fig. 8, Nos. 1, 3, 4, 6, 14, 19, 21, 22). Pseudo-awls at the ends of small blades are very frequent (Fig. 9, Nos. 1-26). There exist four varieties of pseudo-awls:

(1) with the point in the middle of the blade (Nos. 1-7, 9, 10-13, 15, 16).

(2) with right-hand point (Nos. 8, 17, 21, 22, 25, 26).

(3) with left-hand point (Nos. 10, 14, 23, 24).

(4) double-ended point (Nos. 18-20).

The points are either short or long, straight or curved.

Tanged Points: (Fig. 7, Nos. 19, 21, 24, 25). The tanged points are of various forms and techniques.

(1) The whole of one face of the tanged point or the point itself on its lower face was produced by pressure technique.

(2) The tang on one face was trimmed by secondary flaking and the rest of the tanged point was left either untouched or slightly trimmed.

(3) The tang was produced by secondary oblique flaking on both faces; the bulbar face was sometimes trimmed on one or both edges.

Scrapers: These were usually made of thick flakes, seldom of blades; they have mostly convex ends. The scraper with concave end is rare (Fig. 4, Nos. 5, 8; Fig. 5, Nos. 6).

Gravers: Gravers are made on flakes. Most of them are of the angle-type; ordinary gravers of *bec de flute* type are rare; three of oblique form are represented. Single blows are common on flakes or on core-trimmings (Fig. 10, Nos. 7, 8, 9, 10; Fig. 5, No. 9).

Saws and Serrated Flakes: Saws are mostly made of thin rectangular blades. There occur specimens where the two transversal ends are squared or retouched. The teeth are deep and have been flaked from one face or both; the other lateral edge is straight, curved or concave and is either backed steeply, retouched on one or both faces, retouched inversely, or left almost intact. The saws have unilateral as well as bilateral teeth. A variety of saws is shown on Figure 7, Nos. 1-12.

No. 1 has an intact curved back, blunted across the top and the base; the teeth are deep cut and unilateral. No. 2 has a curved back, convex, blunted top; the teeth are deep cut and flaked from both faces. No. 3 has a curved base, the lower concave edge is blunted, the upper concave edge is blunted on both faces; a small notch is on the bulbar face. Teeth are flaked from both faces. No. 4 has a concave back, straight blunted top; the teeth are flaked from both faces. No. 5 has a concave back with large deep

teeth. No. 6 has a straight intact back with large deep teeth. Nos. 7, 8 and 9 have a blunted back and No. 10 has a somewhat rounded back with inverse retouche. Nos. 11 and 12 have bilateral teeth. A number of serrated flakes are shown with large, deep teeth in Figure 10, Nos. 11, 13-16; some notched flakes in Figure 10, Nos. 12, 18, 21.

Atypic Flint Implements: A number of tools comprising core-tools, flakes and blades have been separately considered as being atypic. They include unfinished tools and those accidentally broken in the process of making, as well as implements which were discarded after having been used by the prehistoric inhabitants of this settlement. A group of primary flakes (with cortex) and the debris of flaking as well as small unretouched thin flakes are included. Tools which possessed one or two sharp edges have, however, been used for cutting or scraping as shown by traces of use. Although they are not museum specimens, they afford an opportunity for studying the technique of toolmaking.

Core Trimming Flakes: A number of core trimming flakes have been recorded, most of them have been used as knifes or as scrapers. (Figure 4, Nos. 5, 6, 8).

INVENTORY OF FLINT IMPLEMENTS

Cores with one platform	45	Awls	40
Cores with double platform	66	Pseudo-awls	605
Core-scrapers	7	Gravers	12
Small cores with one platform	34	Saws	203
Small cores with double platform	40	Arrow-heads	30
Small long cores	24	Tanged points	14
Cores, various	68	Serrated flakes	24
Core-trimming flakes	26	Sickle-blades	44
Hammer-stones	12	Scrapers	41
Axes	30	Blades (retouched)	52
Celts and hoes	195	Blades (with 'inverse retouche')	27
Tranchets	16	Notched blades	31
Pick-axes	62	Flakes	914
Celts and hoes (polished end)	48	Blades, various	440
Axes (polished end)	16	Unfinished tools	414
Chisels	14	Total	3,594

STONE OBJECTS: Eccentrically perforated flat stones were used as pendants. The holes, drilled by big flint awls, are biconical and have been made from both ends. In a few cases perforation has not been completed. Some pendants were decorated with shallow carved lines on one or both faces, sometimes these lines radiated from the hole (Fig. 11, Nos. 1-3, 5, 7-9).

MACE-HEADS: A large number of round flat basalt stones, eccentrically perforated by flint awls from both ends; the holes are biconical.

SPINDLE-WHORLS made of basalt, flat stone pebbles or clay with large drilled hole; the spindle-whorls of clay are of biconical shape with smoothed surface and without decoration.

LIMESTONE-CUPS: The interior has been hollowed out and is covered by scorings made with a sharp flint, probably a graver. A fragment of a cup was decorated on the outside with a carved herring-bone ornament.

BONE OBJECTS: Two bone pins or awls were made from a gazelle's metatarsal. Another awl was broken, only the pointed part being found. The pointed ends of the awl are rubbed and smoothed (Fig. 12, Nos. 3, 6-8, 10). Short transversal and equidistant incisions on the rib of a gazelle represent the so-called '*marques de chasse*'. The incisions are transversal to the axis of the rib and are on one surface only (Fig. 12, No. 2). A phalange with perforated hole may have been used as a whistle (Fig. 12, No. 9). A fragment of bone with unsymmetrical incisions (Fig. 12, No. 5). Fig. 12, No. 1 shows a bone spatula; Fig. 12, No. 4 either a spatula or a haft.

BEADS: Sea shells and those of river snails were made into beads. They have small suspension holes.

ART OBJECTS: The many stone carvings found may have a ritual significance in that they represent religious symbols connected with a fertility cult. Something may be learned from them about the spiritual life of the inhabitants of this prehistoric village and about their magical and religious ceremonies. Most of the carvings have been made on flat oval pebbles representing schematic human forms.

Pl. iii, No. 1. Schematic female figure. The outline of the breast is roughly indicated by a carved line. The umbilicus is marked by a round deep hollow. The genitalia are indicated in the same way. Two deep hori-

zontal lines between the genitalia indicate in a conventional manner the folds between the abdomen and the thighs. Basalt. Total length 119 mm.

Pl. iii, No. 2. Schematic female figure, seated posture. Two inclined incisions indicate the abdominal folds, and on the back of the thorax the waist line. Two other incised lines indicate the folds between the abdomen and the thighs, thus indicating clearly the posterior. A deeply carved line between the thighs indicates the genitalia. The back is a slightly convex surface ending in a point. Limestone, total length 80 mm.

Pl. iii, No. 3. A schematic human face made on an elongated limestone pebble. Two short horizontal incisions indicate the eyebrows and a small round depression indicates the mouth. The nose is not marked. Total length 68 mm.

Pl. iii, No. 4. A phallic symbol made of polished pebble of conical shape, sharpened by grinding. Total length 75 mm.

Pl. iv, Nos. 1, 2 and Pl. v, Nos. 1, 2.[2] A standing female figure, with remarkable distinct indication of sex. The neckline too is indicated. Depression indicates the eyes (bad state of preservation). The mouth and the nose are not marked. The exaggerated breasts are indicated by incisions. This line continues on the back. The legs are pointed and divided by an incised line in front; below the incised line there are dots all round. Limestone. Total length 65 mm.

Pl. iv, No. 3. Pyramid with two deep parallel carved lines near the base; above them an oblique incision. Limestone. Total length 77 mm.

Pl. iv, No. 4. Flat ovoid pebble; one side shows a large incised groove representing a vulva. Basalt.

Pl. iv, No. 5; Pl. vi, No. 5. Two oval flat pebbles. On one side nine parallel incisions, on the other five incisions and a small groove in the middle. Basalt.

Pl. v, No. 3. Flat ovoid pebble. A deep groove on one side represents the vulva; six fine incised lines extending from the groove to the edge in one of the segments probably indicate the pubes. Basalt (broken).

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[2] Pl. iv, Nos. 1, 2; Pl. v, Nos. 1, 2 are twice the natural size.

Pl. v, No. 4. Flat oval pebble. 36 squares have been incised on one side. Basalt.

Fig. 11, No. 1. Oval amulet on flat pebble. The biconical suspension hole is drilled right through. Short strokes. Limestone. Total length 65 mm.

Fig. 11, Nos. 3, 5. Spindle-whorl made from flat pebble with drilled suspension hole. Limestone.

Fig. 11. No. 4. Fragment of a pebble with incised squares. Basalt.

Fig. 11, No. 8. Pendant. Roughly oval in shape; biconical suspension hole near one end, drilled with a flint awl from both sides. Limestone. Roughly oval pebble with flattened sides; hole drilled from both faces. Unfinished. Limestone.

Pl. vi, Nos. 1, 2. Flat oval pebble. A deep carved groove in the middle indicates the vulva. Basalt. Total length 85 mm.

Pl. vi, No. 3. Schematic human face on a flat pebble. Two incisions indicate the eyebrows and a large depression the mouth. Basalt. Total length 105 mm.

Pl. vi, No. 4. Schematic human face on a flat oval pebble. Two horizontal incisions indicate the eyes. Basalt. Total length 95 mm.

Pl. vi, No. 6. Schematic human face carved on a cylindrical pebble. The eyebrows are given by two deep short horizontal incisions.

Pl. vii, Nos. 1-1A. Schematic representation of a human face on both sides of a flat pebble. Two deep incisions indicate the eyebrows. Limestone. Total length 95 mm.

Pl. vii, Nos. 2-2A. Schematic representation of female figure on both faces of a flat, oval pebble. Sexual triangle. Limestone. Total length 175 mm.

Two flat pebbles on which animals have been carved. Pl. ii, No. 10 represents a cow (?), Pl. ii, No. 11 probably an *equida* (?).

Another stock of stone carvings was found, mostly broken, the interpretation of which is impossible without additional detailed study; for this reason I reproduce only one of them (obverse and reverse) without any comments (Pl. iii, Nos. 5 and 5A).

POTTERY: Pottery was locally manufactured from clay evidently found on the site. The paste was tempered with coarse sand containing quartz and basalt grits, and with chopped straw. Large grits protrude through the surface of the fragments, the straw having left impressions in the clay after firing. The pots were hand-made and finger prints are visible on the inside of the potsherds. No evidence of the method of firing was found, but an open fire was probably used. The low temperature of the fire did no more than redden the surface. Among the many broken finds were fragments of small pots, platters and closed vessels.[3] Not all pots appear to have been well proportioned and symmetrically built. Different forms and shapes were found. The bases were flat, sometimes with mat-impressions. The bodies were slightly globular; the rims show differences in shape as can be seen in the cross-sections shown in Fig. 12; the edges were finished in various ways; rounded or sloped on the outside or the inside. The thickness of the walls varied in different parts of the same pot. The pots were wet-smoothed, both inside and out. Sometimes a slip was used for the finished surface. The knobs and small loop handles seem to have been ornamental but the loop handles probably served for carrying the pot although the openings were not large enough for the fingers: a suspending string may have been used.

Decoration: The fragments of pottery were decorated on the outside by incisions: herring-bone ornaments arranged in triangular or zigzag lines, or short parallel strokes were drawn with a pointed tool in the clay before firing.

Pl. i, Nos. 1, 3, 4. Fragment of a small closed vessel decorated on the base of the neck with an irregular incised herring-bone pattern between incised lines. Light buff gritty ware, traces of brown slip.

Pl. i, No. 2 and Fig. 13, No. 13. Jar. Fragment of a jar showing a slightly concave neck with plain lip and part of the globular body. Handle plano-convex from shoulder to middle of neck. Incised herring-bone bands at the base of the neck and the body forming triangles or zigzag.

[3] The term 'closed vessel' is used to mean one having an inverted rim, and the diameter at the rim less than that of the body.

Reddish brown slip on outside and on the lip, covering inside of the neck; greyish buff gritty ware, smoothed on outside and on the lip.

Pl. i, Nos. 5, 8. Bowl fragment. Straight sides, plain lip, incised horizontal herring-bone band; remains of a second oblique band.

Pl. i, No. 6. Vessel. Shoulder of closed vessel decorated with slightly raised incised herring-bone band.

Pl. i, No. 7. Fragment of wall of closed vessel. Incised decoration. A triangle filled with oblique strokes. Traces of brown slip. Buff gritty ware.

Pl. i, No. 9. Vessel. Fragment of wall; painted, decorated with two incised lines partly covered with reddish brown slip. Light buff gritty ware.

Pl. i, No. 10. Vessel. Fragment of wall; decorated on outside with horizontal and oblique bands consisting of incised parallel lines. Buff gritty ware.

Pl. i, No. 11. Vessel. Fragment of wall; decorated on outside with incised lines; traces of reddish brown slip; greyish buff ware.

Pl. i, No. 12. Bowl. Fragment of wall decorated on outside with an incised zigzag band filled with oblique strokes. Traces of reddish brown slip; light buff gritty ware.

Pl. i, Nos. 13, 14, 15. Vessels. Fragments of walls; decorated with incised bands resembling the herring-bone pattern. Buff gritty ware.

Pl. i, No. 16. Vessel. Small closed vessel decorated with horizontal and vertical herring-bone bands. Traces of applied handle at the junction of the bands. Traces of reddish brown slip. Light buff gritty ware.

Pl. i, No. 17. Bowl. Fragment of wall decorated on outside with incised herring-bone band forming a triangle and zigzag pattern. Traces of reddish brown slip. Buff gritty ware.

Pl. i, No. 18. Vessel. Fragment of wall of closed vessel, decorated with double triangle or zigzag; traces of brown slip. Buff gritty ware.

Pl. i, No. 19. Vessel. Fragment of wall of an open vessel, decorated with horizontal band, consisting of incised parallel lines. Traces of reddish brown slip. Light buff gritty ware.

Pl. i, No. 20. Vessel. Fragment of a closed vessel, decorated with a raised triangle consisting of an alternating herring-bone ornament. The

bands are separated by incised lines. Traces of reddish brown slip. Coarse gritty yellow buff ware.

Pl. ii, No. 1 and Fig. 13, No. 2. Jar. Fragment of rim, flat-topped lip above an applied knob handle. Very rough interior surface. Light buff gritty ware.

Pl. ii, No. 2 and Fig. 13, No. 14. Vessel. Fragment of small globular vessel with short grooved neck. Fragment of the handle shows that it reached from the shoulder to the neck of the vessel. The vessel was decorated with incised-double lines; one horizontal line on the neck and several oblique ones forming a triangle on the body. Buff gritty ware. Traces of reddish-brown slip on outside and inside.

Pl. ii, No. 3 and Fig. 13, No. 16. Bowl. Fragment of a flat base from a thick walled bowl with flat disc base. Greyish buff ware.

Pl. ii, No. 4 and Fig. 13, No. 1. Jar. Fragment of rim. Straight walls with everted rim. Small horizontal lug handles of which only one and a half remain. Light buff gritty ware.

Pl. ii, No. 6. Fragment of flat base and adjoining portion of walls. Buff gritty ware with chopped straw.

Pl. ii, No. 7. Spindle-whorl with biconical hole. Coarse gritty ware.

Pl. ii, Nos. 8 and 8A. Jar. Fragment of a handle curving from shoulder to neck. Incised raised band on the base of the neck. Buff gritty ware.

Pl. ii, No. 9 and Fig. 13, No. 11. Platter. A basal fragment of a platter, of which part of the base and the sides with handles have been preserved; everted straight sides and thickening flat-topped rim: flat base with mat-impression (shown, enlarged, in Pl. ii, No. 9A). Flat-topped horizontal handle, with small suspension-hole, applied below the rim. Coarse reddish-buff ware, straw-tempered.

THE MATERIAL CULTURE AND ITS INTERPRETATION

A close examination of the material culture confirms the presence of an important post-Mesolithic cultural phase which is represented in the prehistoric settlement of Sha'ar ha-Golan.

This settlement was occupied for a long period of time, and its pre-

historic settlers were the bearers of something new, although very little of their social and economic life is known to us. We should, therefore, try to find its exact place in the chronology of the prehistoric civilization of Palestine.

The presence of a number of mortars hollowed in large basalt-blocks, pestles, pounders and querns of basalt, picks, hoes, sickle-blades made of flint or chert—all these implements are a proof that the basic life of the Yarmuk population was horticulture in its very primitive stage.

But there is no clear evidence of cereal cultivation, though pounders and querns could be used for preparing wild grain; the sawing of animal bones or fresh boughs with toothed flint blades could produce glossy serrated edges. Bones of animals, such as calves, goats, sheep and dogs show that pastoralism was known.

It is, however, clear that neither horticulture nor pastoralism in their primitive stages alone could be the economic basis of the Yarmuk population. Flint arrow-heads and darts, broken bones of animals such as wild boar, gazelle, camel and birds, indicate that hunting was practised by them, and that the animals had been killed for food and the bones broken for the extraction of the marrow; many of the bones had been cut by flint blades. Animal bones were used for the manufacture of bone tools. All these prove that hunting was of some importance to the people's economy.

Positive evidence for fishing has been discovered: heavy stone sinkers for fishing-nets were found.

The existence of a primitive, local textile industry is proved by the discovery of spindle-whorls and loom-weights. Woodworking was practised as axes, celts, tranchets of flint or chert, adapted for such work, have been collected. Basketry was also developed.

The settlers possessed a well-developed flint industry. The flint implements have been carefully knapped, some of them made by pressure flaking retouche; some of the core tools have been polished on the working edge. The settlers made coarse hand-made ornamental pottery, baked in open fire.

No specific evidence of trade with people of other stocks occupying regions remote from the site was discovered. The trade in shells does

not seem to have been extensive as only a few fluvial shell beads and a fragment of a marine shell were found.

As far as we can judge from the material culture discovered, this prehistoric community appears to have been largely self-sufficient.

The arts of carving and engraving were practised and are very characteristic of the prehistoric settlement; they are proof of a highly developed spiritual life among the population. The material culture of the settlement is remarkable and no similar parallel is known either in Palestine or elsewhere in the Ancient East. This prehistoric culture must be considered as completely unknown until now. For that reason, I have named it 'Yarmukian', after the Yarmuk River, which played an important part in its development.

The Yarmukian is remarkable for the absence of the characteristic elements of Chalcolithic culture; it is a Neolithic culture.

Unfortunately, the existence of a Neolithic phase in Palestine has been denied by certain archaeologists. Even excavations at Jericho[4] (IX—XII), and in the cave of Abu Usba',[5] where there are definite Neolithic characteristics, have not convinced a number of the leading authorities, whose opinion has been that no 'true Neolithic culture flourished in Palestine', and that 'Neolithic' was not legitimate in the chronological sequence of prehistoric Palestine.

The Neolithic culture of Palestine and of the whole Ancient East belongs to the 'dark age' cultures and provokes much speculation. The problem is a complicated one and cannot be solved by theories, but only by facts brought to light by field work. For this reason, opinions against the existence of a Neolithic phase should not be considered final, even though these opinions have been accepted by a number of leading scientists.

The whole problem of post-Neolithic civilization is no longer a ques-

[4] Crowfoot, J.: Notes on the Flint Implements of Jericho. *Ann. Archaeol. & Anthropol.*, Liverpool, 22, 1935, pp. 174-184; 24, 1937, pp. 35-51.

[5] Stekelis, M.: Preliminary Report on Soundings in Prehistoric Caves in Palestine. *Bull. Amer. Schools Orient. Res.*, 86, 1942, pp. 2-10; id.: Further Observations on the Chronology of Mugharet Abu Usba', *ibid.* 89, 1943, pp. 22-24; id.: Excavations in Palestine and Trans-Jordan, 1940-1.—Prehistoric Caves. *Quart. Dept. Antiq. Palest.*, 11, 1944, pp. 115-118.

tion of mere terminology, but rather one of the correct interpretation of different cultural phenomena. The post-Mesolithic period began with a Neolithic phenomenon in which different cultural phases have been developed. Each phase has its own characteristics and can be easily recognized.

The flint industry and the pottery of the Yarmukian are different in types, forms and technique from the leading types of the Chalcolithic culture. The art objects of the Yarmukian have a character of their own and cannot be compared with those of the Chalcolithic period.

Excavations at Jericho (IX-XII) and in the caves of Abu Usba' and 'Iraq el-Barud on Mount Carmel have proved sufficiently the presence of Neolithic cultural phases in Palestine to which the Yarmukian should be added. The post-Mesolithic civilization with its complicated Neolithic phenomena was of long duration in Palestine.

If we compare the Yarmukian with the Neolithic of Jericho (IX-XII), we shall find that these two cultures differ in many ways. The typical flint tools of Jericho of the so-called Tahunian type, obsidian implements and art objects are not the same as those of the Yarmukian culture and it seems that the Neolithic of Jericho belongs to a more advanced phase. The Neolithic layers of the Abu Usba' and 'Iraq el-Barud caves belong to an older phase. This culture, which I have named 'Usbian', belongs to the very beginning of the post-Mesolithic civilization, for the technique and the form of some of its tools are plainly characteristic of the Mesolithic (Natufian): the micro-graver still exists. But in the Usbian phase there appear also new forms of tools made by a new technique, strange to the Mesolithic (Natufian) on the one hand, and to the Chalcolithic on the other. This industry is accompanied by crude hand-made pottery. The abundant fauna is Mesolithic, with modern types occurring as well. It is clear that the Usbian culture derived directly from the Natufian and represents the earliest phase of the Neolithic: the Usbian followed by the Yarmukian.

The Usbian, the Yarmukian, and the Jerichoan, in this order, though not necessarily consecutive, are phases of the immediately post-Mesolithic civilization which formed the Neolithic cultural complex and filled the

gap between the end of the Mesolithic (Natufian) and the beginning of the Chalcolithic—a gap of over three thousand years—as shown in the following table:[6]

Mesolithic	End of Natufian	c. 8,000 B.C.
Neolithic	Usbian	c. 7,500 B.C.
	Yarmukian	c. 7,000 B.C.
	Jerichoan	c. 5,500 B.C.
Chalcolithic	Beginning of Ghassulian	c. 4,500 B.C.

[6] The dates in the Hebrew version of this paper were, in error, printed wrongly in *Eretz-Israel*, Vol. 1; that error has here been corrected.

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Caesarea
A Study in the Decline of a Town

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THE decay of ancient civilizations can probably be studied best in the countries of the Levant. Here many a flourishing city has been reduced to ruins and fertile fields have become pestilent swamps or have been buried by moving sand.

Caesarea, on Israel's coast, founded in 22 B.C. by Herod at a place formerly called Strato's Tower, and its harbour Sebastos are a classical example in this respect. Josephus, describing the magnificent work carried out by the king writes as follows: 'For the whole sea-board from Dora to Joppa, midway between which the city lies, was without a harbour, so that vessels bound for Egypt along the coast of Phoenicia had to ride at anchor in the open when menaced by the south-west wind; for even a moderate breeze from this quarter dashes the waves to such a height against the cliffs, that their reflux spreads a wild commotion far out to sea. However by dint of expenditure and enterprise, the king triumphed over nature and constructed a harbour larger than Piraeus, including other deep roadsteads within its recesses . . . Notwithstanding the totally recalcitrant nature of the site, he grappled with the difficulties so successfully that the solidity of his masonry defied the sea . . .'[1] Josephus knew about the south-westerly winds which throw the sand on the beaches[2] and, indeed, the whole stretch of this coast is perpetually menaced by the forces

* Plates viii/ix, xi and xiv are reproduced from the author's Hebrew book *The Struggle between the Desert and the Sown* by kind permission of the Bialik Foundation, Jerusalem.

[1] Josephus: *BJ*, I, 21:5-7.

[2] Josephus: *Ant.*, XV, 9:6.

of nature. The surf demolishes the shore-line, and eats into the rocks of calcareous sandstone. The latter crumble into easily movable sand. At the same time there is a constant transport of sand along the coast from south to north by coastal drift and longshore currents.

There is usually a tendency to bring about an equilibrium between the forces of erosion exerted by the incoming waves and the accumulation processes due to shore currents. When this delicate balance is reached the slope of the beach is barely steep enough for the seaward currents to return the material that is driven toward the shore by the incoming waves.[3] This equilibrium, however, can be disturbed by human activity such as the construction of a mole. In this case the sand moved by the sea will be deposited in front of the impediment and will slowly move inland in the form of dunes, the direction of movement being determined by the prevailing wind. In other words, the equilibrium will be destroyed in favour of sand accumulation. Beyond the impediment, however, sand will not accumulate, but processes of erosion and destruction by the surf will prevail. This is what has happened in the case of the mole built by Herod at Caesarea[4] (Pl. viii/ix, No. 1). In front (south) of this, sand has been deposited by the south-north current, and has then been driven inland by the prevailing south-westerly wind: beyond it, to the north, the sea has eaten into the land, and at least 500,000 tons of rock and soil have been eroded. At the same time the so-called 'High Level Aqueduct' (Pl. ix, No. 9), constructed in the second century A.D., has been destroyed. But step by step processes of accumulation have again gained predominance and the sand has crossed this aqueduct menacing the so-called 'Low Level Aqueduct' (Pl. ix, No. 8) constructed at about the same time. In order to protect the latter against the encroaching sand it was covered by a vault, probably in the 10th or 11th century A.D. Today this aqueduct too is fully covered by moving sand.

When not held in place by vegetation the sand thrown on the beach

[3] Worcester, P. G.: *A Textbook of Geomorphology*. New York, 1939. Ref. pp. 395 ff.

[4] Rim, M.: *The Movement of Dunes and the Origin of Red Sand in Palestine from a Physical Point of View*. (Hebrew) Thesis, Hebr. Univ., Jerusalem, 1948.

invariably moves inland covering everything on its way. We therefore find that with the exception of a small stretch the whole territory of ancient Caesarea is now covered by sand dunes. This small stretch, embracing the Crusader City, has been left free because of the steepness of the old harbour installations which prevented sanding-up of the beach at this particular point.

Notwithstanding the talmudic passage that Caesarea is embedded between dunes[5] the town was, of course, free of sand in ancient times when artificial construction and vegetation prevented the expansion of sand dunes. The aerial photograph (Pl. viii/ix) reveals the extent of the ancient town which, due to human neglect, is now fully covered by dunes as are the splendid aqueducts and the fields and gardens once famous for their fertility. The dunes now stretch 4 kilometres inland at various places and had, until drained a few years ago, impeded the outflow of the Mefjir River thus causing a highly malarious swamp. The formation of the Kabara swamps to the north is due to the decay of the old irrigation work and will be described later.

Various measurements carried out by our laboratory show the dune sand to move at a rate of about 2-4 metres per year. An excavation carried out by the Palestine Government showed an accumulation of dune sand to a height of about 2½ metres in the town area since Roman times. But this dune sand has, on the other hand, preserved to us not only the ground plan of the town, but also the remains of various other buildings and the full course of the 'Low Level Aqueduct'. In addition the aerial photograph revealed an amphitheatre the existence of which had not previously been known (Pl. viii/ix and map Pl. xvi).

The Town. A semi-circular wall (Pl. ix, No. 7), surrounding the main part of Roman Caesarea with its public buildings, is clearly discernible on the photograph, but it can also be seen that the town extended for about 2 kilometres further southward (Pl. viii/ix, left). This southward extension was apparently made necessary by the increase in the number of its inhabitants. The town was constructed according to a plan, in which regular

[5] Talm. Bab. *Megilla* 6a.

streets divided it into approximately 300 blocks or quarters *('insulae')*. Each of these blocks was, as far as can be ascertained from the photograph, about 90 metres long and 50 metres broad. This compares with insulae found at Dura which were 100 metres long and 40 metres broad. In Palestine itself such blocks have actually been excavated at the Samaria of Gabinius.[6] The fact that the streets abutting on the harbour were laid at equal distances apart is especially mentioned by Josephus.[1] The latter also describes the elaborate canalization system which was of the utmost importance for a town which had already 50,000 inhabitants at the outbreak of the Jewish War. The outlines of an immense public building (approx. 100 × 100 metres) are discernible on the hill just east of the modern Jewish settlement (Pl. ix, No. 3) and ground observation showed a straight line of remains, including a column protruding through the sand with a rectangular prolongation in a westerly direction. Only excavation will show whether we have in these remains the vestiges of Caesar's temple which stood on an 'eminence facing the harbour-mouth' and was remarkable for its 'beauty and grand proportions'.[1] This temple was visible to sailors from a long distance and it seems hardly possible to locate it at the rather low-lying place where the remains of a Crusader basilica are situated.[7]

The part of the town now buried under the sand is described in the 10th century A.D.[8] as 'a well populated suburb without the strongly walled city'; and that it still existed in the 12th century[9] is also proved by the immense quantity of potsherds strewn all over the place, of which quite a high proportion can be assigned to this period. On the other hand, the above-mentioned excavation carried out by the Palestine Government resulted in the finding of a Roman villa with marble floor and an inscribed column. Besides, the great percentage of Roman pottery found on the dunes is ample proof that the buried city already existed in Roman times.

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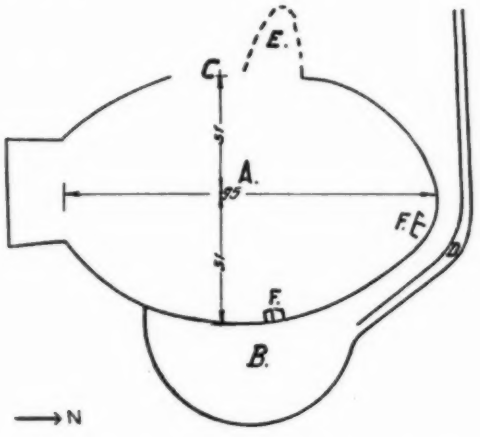
[6] Watzinger, C.: *Denkmäler Palästinas*, II. Leipzig, 1935. Ref. pp. 12, 16.
[7] Haefeli, L.: *Cäsarea am Meer*. Münster, 1923. Ref. p. 19.
[8] Muqqadasi: *Description of Syria*. Palest. Pilgrims' Text Soc., London, 1886. Ref. p. 69.
[9] Idrisi, quoted from Guy Le Strange: *Palestine under the Moslems*. London, 1890. Ref. pp. 475 ff.

The Harbour. Josephus describes in detail the harbour constructed by Herod.[1,2] From his description it becomes clear that the still extant theatre[10] was to the south of the harbour. The mole started just north of this place and can still be recognized (Pl. ix, No. 1, left). Its breadth of 60 metres agrees well with the measurements given by Josephus. Josephus states[1,2] that in order to prevent sanding-up of the harbour by littoral currents and to use the most favourable north wind its entrance was on the north side and that to the left of the entrance a massive tower was situated. The foundations of this tower are still visible on the photograph (Pl. ix, 1 left).

The mole, half of which acted as breakwater[1,2] apparently encircled the harbour to a point north of it.

The Public Buildings. The remains of most of these buildings can probably be found only by excavation. A possible location of the temple has



THE ROMAN AMPHITHEATRE AT CAESAREA

Legend

A. Axis of arena
B. Raised platform
C. Entrance
D. Carriage road to platform
E. Subterranean passage
F. Stone benches

[10] Conder, C. R. & Kitchener, H. H.: *The Survey of Western Palestine.* Mem. II., London, 1882. Ref. pp. 20 ff.

already been mentioned. The hippodrome (Pl. ix, No. 5) and a theatre (Pl. ix, No. 4) mentioned by Josephus,[1,2] have long been known. But the aerial photograph has revealed also the hitherto unknown amphitheatre described by Josephus (Pl. ix, No. 6). The arena of this amphitheatre (Pl. x, Fig. 2, and plan) is 95 metres long and 62 metres broad with which the arena of the Colosseum, 86 metres long and 54 metres broad, may be compared. The proportion of length to breadth is in both cases approximately the same, namely 1.6 at Caesarea and 1.53 at Rome. To the east of the arena is a raised platform about three metres higher than the present ground of the arena. The arena was covered with rough mosaics, whereas the floor of this platform was covered with finer stones. From the platform a carriage road led to the sea shore and its remains can be detected on the aerial photograph. Remains of stone benches (Pl. x, 2) and an entrance with subterranean passage to the west are still extant. 65 metres to the west are the remains of a tower and 70 metres to the south-west are the ruins of a large building, apparently of late Byzantine times.

The situation of this amphitheatre does not conform to the description of Josephus[2] who writes as follows: 'Besides Herod built a theatre of rock-cut stones in the town and behind it, on the southern side of the harbour, an amphitheatre which was able to accommodate an immense crowd and was so suitably situated that it allowed for a wide view over the sea'. Now the building to the south of the harbour was a theatre and not an amphitheatre. It seems therefore that this passage has to be amended by changing 'amphitheatre' into 'theatre' and vice versa. This would also meet the postulate that a wide view could be obtained over the sea, which is true for the theatre only. Neither from the amphitheatre nor from the hippodrome can a wide view over the sea be obtained. Besides, the mistake can easily be explained by the fact that the word amphitheatre occurs first with Dionysius of Halicarnassus about 30 B.C. and strangely enough the first permanent amphitheatre was built in Rome only in 29 B.C. by Statilius Taurus in the Campus Martius.[11] Neither the theatre nor the hippodrome

[11] Friedländer, L.: *Darstellungen aus der Sittengeschichte Roms*, II. Leipzig, 1889. Ref. pp. 526ff.

was the place for gladiatoral and wild beast combats. The place for such contests was the amphitheatre and since we know that at the inauguration of the town in 10 B.C. such combats were performed[12] it is most probable that this amphitheatre is really the one built by Herod, and the place where hundreds of Jewish prisoners of war were killed in gladiatoral and wild beast combats by Titus eighty years later.[13] It may be mentioned that animals from India and Ethiopia were exhibited by the Emperor Maximinus at Caesarea on the occasion of his birthday, and the *ludi circenses* of Caesarea were still famous in the 4th century A.D.[14]

The Aqueducts. Nowhere does Josephus mention the building of aqueducts and contrary to former opinion these water conduits must be ascribed to later times. It may be supposed that in the beginning the population had to depend, as in most Palestinian cities of the time, on rain water and wells: ground water is easily struck in Caesarea at a depth of only a few metres.

The High Level Aqueduct. According to two Roman inscriptions[15] this aqueduct was built by detachments of the 6th and 10th Roman legions (first half of the second century): it is also mentioned in a talmudic passage of the 4th century.[16] It takes its origin at the Ras en-Neba spring about 7 kilometres to the north-east of the town at the foot of the Carmel range. Here a dam was constructed to raise the water level. The spring has an output of about 0.9 cu.m./sec and the water is of excellent quality. A second conduit, bringing water from the Carmel range augmented this supply (cf. plan, Pl. xvi).

In this way water was brought to Caesarea from a distance of over 12 kilometres. The aqueduct starts as a rock-cut channel,[17] is later supported by

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[12] Josephus: *Ant.*, XVI, 5:1. [13] Josephus: *BJ*, VII, 3:1.

[14] Schürer, E.: *Geschichte des Jüdischen Volkes im Zeitalter Jesu Christi*, II. Leipzig, 1907. Ref. pp. 50-1.

[15] Vilnay, Z.: A New Inscription from the Neighbourhood of Caesarea. *Quart. Stat. Palest. Explor. Fund*, 60, 1928, pp. 45-47, 60.

[16] Talm. Jer. *Demai*, 2:5.

[17] Mülinen, E. Graf von: Beiträge zur Kenntnis des Karmels. *Zeitschr. Deutsch. Paläst. Ver.*, 30, 1907, pp. 117-207; 31, 1908, pp. 1-258.

a rubble wall and finally led over semi-circular arches (Pl. x-xii, Figs. 3, 4 and 5). From the foot of the mountain the aqueduct turns due west and crosses the Zerqa River on a bridge. Here it becomes double, each channel having a diameter of 45 cms. and containing three earthenware pipes. These pipes apparently acted as a syphon, the level of the swampy ground past the bridge being lower than the eastern part of the aqueduct. The swampy nature of the land caused serious trouble to the foundations of the aqueduct, which sank and necessitated the building of a deviation. But the deviation too caused serious trouble and again and again the arches had to be supported (Pl. xi, 4). Another means used to raise the level of the flow was to lay new layers of rubble, cemented with mortar, on the conduits. These repairs are apparently alluded to by the Christian writer Chorikios[18] who states: It also happened in the reign of Justinian (6th century) that the Caesarea aqueduct 'bringing water from bright sources and clear rivulets flowing 50 stadia (9 kms.) to the east of the town stopped, because of negligence to allow a free passage of the running water'. Thus it happened that the public fountains dried up completely, or delivered too little water, which caused fights among the people coming to the fountains. This was truly the 'changed city' of the poets and what was still more distressing was 'that the springs continued to flow to the shame of the negligence, making the discouragement of citizens still more bitter; since whatever is agreeable does not vex people who can use it so much if it is far away than if it is near'. Happily the governors of the time knew how to meet this calamity by opening a free flow to the running water and multiplying the number of fountains: the obstacles had been removed by skilled technicians.

After crossing the swamp the conduit is tunnelled through a ridge of soft calcareous sandstone (Pl. x, 5) and beyond this it turns due south in the direction of Caesarea. Here it can be seen that the channel was doubled at a later period, the western conduit being built after the eastern was completed. The whole section of the aqueduct running N-S along the sea-shore is now almost completely covered by dune sand, although its

[18] Abel, F. M.: *Géographie de la Palestine*, I. Paris, 1933. Ref. p. 449.

height here is almost 6 metres and its breadth over 5 metres. (A detailed description will be found in the *Survey of Western Palestine*.[10]) Incidentally, level observations by Rim[4] show that there have not been any appreciable processes of submergence or emergence of the coast since historic times, the level of the aqueduct near the coast being slightly lower than near the entrance at the swamp. On the other hand, as mentioned before, about 500 metres before reaching Caesarea the aqueduct suddenly breaks off, the sandstone ridge on which it was built having been completely eroded by wave-action (Pl. viii/ix and Pl. xii, 6). It seems that it is this aqueduct to which Albert of Aachen refers in 1101[19] when he writes: '*ibidem ad radicem montis fons manant, qui ibidem urbi influit per camporum apertam planitiem*'. In any case the High Level Aqueduct did not function any more in 1166 when a certain Hugo of Caesarea stipulates in a contract:[20] '*si aliquo tempore antiquum conductum predicti fontis reficere voluere et ipsum fontem ad Casale Bubalorum ducere ad canamellas faciendas—mihi liceat*'. This shows that it was already out of the question to lead the water to Caesarea, probably because of the destruction by the surf. In any case in 1283 the monk Burchardus, although speaking of the great swamp east of the city which gives rise to sweet water, does not mention any more either of the aqueducts.[21]

The Low Level Aqueduct. This aqueduct was apparently constructed in order to augment the water supply of Caesarea for agricultural purposes, a tower with pipes leading in different directions having been found by the author several hundred metres north of the city. The water was taken from the Zerqa River near its mouth and thus, having crossed the swamp, it was less fit for human consumption than the clear Ras en-Neba spring water. In order, however, to lead this water to Caesarea an ingenious hydraulic system had to be installed, since the level of the Zerqa River near its mouth (about sea-level) is several metres lower than the land near

[19] Albertus Aquensis: *Historia Hierosolymitana*, cap. 41 and 55.

[20] Röhricht, R.: Studien zur mittelalterlichen Geographie und Topographie Syriens. *Zeitschr. Deutsch. Paläst. Ver.*, 10, 1887, pp. 195-345. Ref. pp. 209, 247.

[21] Burchardus of Mt. Zion: *A Description of the Holy Land*. Palest. Pilgrims' Text Soc., 4. London, 1896. Ref. p. 20.

Caesarea (cf. plan, Pl. xvi). For this reason a dam was built across the Zerqa River (Pl. xiii, 7), the top of which (9.33 metres high) still serves as a bridge. In order to prevent the spreading of the water northwards a second dam about 1 km. long, was built across the marsh, connecting the Carmel slopes with Tell as-Sarris, a knoll to the west (Pl. xv, 10). Both dams enabled the construction of several water mills, those at the Zerqa dam still functioning about a hundred years ago.

The northern dam is built of headers and stretchers and a description of it was given by Schumacher.[22] Comparing its construction with similar walls at Beth She'arim, Dr. Maisler is inclined to date its construction to the third century A.D. The artificial basin thus created by the two dams collected the waters of the Zerqa and its tributaries and, even after deduction of the water led by the 'High Level Aqueduct' to Caesarea, yielded a flow of over 2 cu.m./sec. The water was led into a rock-cut channel (Pl. xiii, 8) near the Zerqa dam and on southwards towards Caesarea which is about 5 kilometres distant from this point, producing the fertility of the region mentioned by many authors. This aqueduct, the line of which can be clearly traced on the aerial photograph, crosses the High Level Aqueduct at one point, but mainly runs parallel with it near the sea shore (Pl. xiii, No. 8). At a later date, (cf. p. 21) it was vaulted with masonry in order to protect it against the encroaching sand dunes. This vault originally had a height of over 2 metres, but is now completely covered by sand (Pl. xiv, 9). It was entering through this aqueduct that the victorious Moslems conquered the town from the Byzantines in 639/40 A.D.[23]

THE DECAY OF CAESAREA

In 985 A.D. the town is still described as beautiful, its lands as excellent and its fruits as delicious.[8] But the same source states 'that the drinking water of the inhabitants is drawn from wells and cisterns'. Since,

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[22] Schumacher, G.: Researches in the Plain North of Caesarea. *Quart. Stat. Palest. Explor. Fund,* 1887, pp. 78-90. Ref. p. 80.

[23] Al-Baladari and Yakut, quoted from *Sepher ha-Yishuv,* II. edit. by S. Assaf & L. A. Mayer. Jerusalem, 1944. Ref. pp. 54/5. (Hebrew).

however, the Persian writer Nâsir-i-Khusrau[24] in 1047 praises Caesarea as being a fine city with running waters'... 'and with fountains that gush out within the City' it seems possible that a repair, perhaps the previously mentioned vaulting of the Low Level Aqueduct, had been carried out in the meantime. This Low Level Aqueduct was apparently still functioning much later since not only the lake created by the two dams is mentioned in a Crusader document of the 12th century (cf. p. 28, n. 20) but the irrigated gardens of Caesarea are still described by William of Tyre,[25] and even in 1220 Jacques de Vitry praises *'hortorum et pascuorum et aquarum fluentium plurimam . . . ubertatem'*.[26] As stated before, no more mention is made of the aqueducts in the late 13th and the 14th centuries, and in 1321 the city altogether was but a ruin.[9] When the irrigation system so carefully maintained for a millennium decayed the waters at the Zerqa dam did not pass the barrage any more at a determined speed, the encroaching sand impeding its flow. At some later date the dam became fully choked and the waters were retained and forced to deposit their silt, causing a rising bank which reduced the speed of the water more and more in the Zerqa river-bed and its tributaries.[27] This again caused a silting up of the river banks and favoured the encroachment of vegetation. All this led to the water spreading all over the plain, causing stagnant water and the swamping up of the whole region.[27] And, indeed, before PICA drained the Kabara swamp it had a luxuriant vegetation of sedges, canes, tamarisks, asphodels etc. The soil had deteriorated at many places; some of the springs emerging in the basin having a high salt content caused the latter to accumulate in the soil. The soil shows a Chlorine content as high as one per cent at various localities. The whole region had become a malaria-infested swamp.

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[24] Nasir-i-Khusrau: *Diary of a Journey.* Palest. Pilgrims' Text Soc., 4. London, 1896. Ref. p. 20.
[25] Propst, H.: *Die geographischen Verhältnisse Syriens und Palästinas nach Wilhelm von Tyrus.* Geschichte d. Kreuzzüge, II. Leipzig, 1927. Ref. p. 14.
[26] Vitriaco, J. de (Vitry, Jacques de): *Historia Hierosolymitana,* cap. 24, quoted from Relandus, H.: *Palaestina ex monumentibus veteribus illustrata.* Traj. Batavorum, 1714. Ref. p. 676.
[27] Caron, L.: *Projet d'assainissement et d'irrigation des terrains de Kabbara. (Jewish Colonisation Association)* Manuscript, 1922.

The splendid town founded by Herod became a metropolis, *'Judaeae Caput'* under Roman rule, and it was the metropolis of *Palaestina Prima* in the 3rd, 4th centuries and the first half of the 5th century. There were important rabbinical schools at Caesarea and not only the remains of a synagogue, but also numerous Jewish tombstones have been found there. As for Christian schools, we need only mention Origines and Eusebius who had their seat there. The town remained one of the most flourishing places of Palestine throughout centuries. Fruits at the market of Caesarea are mentioned in the Tosefta.[28] Even after the Arab conquest the town is still described in 985 A.D. 'as beautiful—its lands as excellent and its fruit delicious'.[8] In 1047 its 'running waters and palm gardens and orange and citron trees' are praised.[9] About 1100 A.D. Albert of Aachen[10] speaks of the immense fruit plantations in the surroundings which were as densely planted as the thickest forest, and which were incredibly luxuriant. And although the fruit trees were destroyed by King Baldwin the fertility of the fruit gardens and the sugar cane plantations was still praised in the 12th and 13th centuries. In the 13th century Caesarea suffered the same vicissitudes as all the vassal towns of Palestine. In 1220 the town was conquered by the Egyptian sultan and in 1251 reconquered by Louis IX of France. In 1265 Baybars destroyed it and the Arab geographer Yakut[29] gives the following description: 'Of old a fine grand city, the very mother of cities, with broad lanes and wide domains; but now it is more like a village'. The work of destruction was finished in 1291 by Sultan al-Ashraf and it is small wonder that Sanutus in 1306 only speaks of the great swamp to the east of the city. The Arab geographer Abu el-Fida[28] finally mentions that the city is but a ruin. Following the destruction by the Egyptian Mameluks the sand encroached everywhere and the whole region became malaria-ridden as few places in Palestine. It is significant that of 77 places in the territory of Caesarea which were still cultivated in the times of the Crusaders only 37 are inhabited today.[30]

[28] Ohalot 18, 16 (ed. Zuckermandel, p. 617, l. 16).

[29] Le Strange, G.: *Palestine under the Moslems.* London, 1890. Ref. pp. 474 ff.

[30] Beyer, G.: Das Gebiet der Kreuzfahrerherrschaft Caesarea in Palästina siedlungs- und territorialgeschichtlich untersucht. *Zeitschr. Deutsch. Paläst. Ver.*, 59, 1936, pp. 1-91. Ref. p. 58.

Caesarea still had a numerous Jewish population at the time of the Arab conquest, but in the 12th century Rabbi Benjamin of Tudela found only two Jewish families there. It seems that a small Jewish settlement was again founded at Caesarea in the 17th century[31] but in the same century the region was also occupied by the Saqr Beduins.[32] The Muslim refugees from Bosnia, settled there in 1884, mainly used the ruins as a convenient quarry, shipping the well-cut stones to Jaffa and Acre.[33]

There are few places in Israel that tell the story of 'man-made deserts' so impressively as Caesarea.

[31] Roger, E.: *La Terre Sainte*. Paris, 1664.

[32] Volney, M. C-F.: *Voyage en Syrie et Égypte*. Paris, 1787. Ref. p. 164.

[33] Benzinger, J.: Der heutige Zustand der alten Denkmäler in Syrien und Palästina. *Zeitschr. Deutsch. Paläst. Ver.*, 14, 1891, pp. 69-74. Ref. p. 71. Thiersch, H.: 2. Archäologischer Jahresbericht. 3. Caesarea Palaestinae. *ibid.*, 37, 1914, pp. 62-3.

Sand and Soil in the Coastal Plain of Israel

A Study of the Rate of Accumulation

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A. INTRODUCTION

By its peculiar geographical position and the ample archaeological and historical evidence available, Israel provides a unique opportunity for natural science to identify and study slow processes and trends that otherwise could not be recognized or timed. Natural equilibria are usually unstable where different geomorphological regions, governed by incompatible physical laws, are in close proximity. Consequently powerful forces become pent up along the borders of these regions. Such is the case in Israel, which is closely surrounded by the sea, deserts and mountain areas. Even human interference, as local history proves, can casually upset natural equilibria and thus start certain directed processes. Although often imperceptibly slow at the beginning, such persistent processes may eventually cause much harm. The scientist and the modern planner depend mainly on archaeological and historical evidence for the understanding and study of such events, but both the archaeologist and the historian quite often benefit from such studies in return. The processes may take the form of climatological or vegetational cycles, isostatic movements or, as in our case, perpetual erosional and depositional processes and rock and soil formation.

B. ALLUVIAL MATERIAL

The accumulation of eroded material from the hills is conspicuous in most valleys and plains. The rate of accumulation is readily determinable where the dating of levels is made possible by the presence of indicators

such as old buildings, ancient bridges and dams, embedded implements, or roots of former trees. On such evidence Prof. Reifenberg has estimated the average rate of erosion in the hilly region to be of the order of one millimetre annually. Accordingly, the coastal plain may be assumed to rise annually by about the same amount on the average. The eroded area is about equal to the area of deposition if we take into account the fact that secondary erosion does not play an important rôle, a continuous sandstone ridge all along the shore impeding the drainage of the whole coastal plain.

On the contrary, sand is making its way inland from the sea, thus contributing to an additional annual rise of the coastal plain and blocking the few river outlets. The absence of any tendency of these river outlets to form deltas also seems to indicate that most of the alluvium from the hills is deposited and retained on the coastal plain.

A comparison between the existing deposition-erosion equilibrium and the effect of quantitative retention has been made possible by a Roman dam, which crosses the coastal plain somewhat to the west of Zikhron Ya'aqov (cf. the plan, Pl. xvi). By the erection of this dam a closed basin was formed on its southern side, while on the northern side the area has been starved of sediment. The depth of sediment trapped on the dam's southern side within approximately 1000 years, reaches three metres at various places. That deposited on the northern side averages about half of the depth observed on the southern side. On the whole, the assumption of an average annual 1 mm. rise seems to be confirmed by this observation.

It has been possible to study the mechanism and the rate of alluvial processes by means of model experiments, and by one-period observations in nature. Archaeological evidence, however, has the advantage of permitting the material to be analysed and the structural and chemical processes involved to be timed.

An opportunity to utilize such evidence is afforded by the Malaha and Kabara swamps, which were formed incidentally when the Romans built the above-mentioned dam and simultaneously closed the outlet of the Crocodile river by another one. The material that has since accumulated

there has developed a number of distinct horizons as a result of directed water movements within the mass of sediment. All the soluble components have become concentrated in the upper layer because, under local climatic conditions, annual evaporation from a permanently wet or vegetated area is in excess of annual rainfall. The high salt content there (up to 7%) is reduced seasonally by the rains, but restored again during the summer wherever the surface is close to the water table. Since PICA drained the area some twenty years ago, most of the salts have been washed down irreversibly by the rain, and most of the area has therefore become arable land.

The present lowered water table coincides with a whitish *gley*-horizon at about 1.8 metre depth. It cannot yet be decided whether response to the new water table has been so quick as to cause the creation of this horizon by elution, or whether it is actually an old horizon, which merely made the new water table halt at its present level.

Another indicator for the depth of accumulated material and its behaviour is the high level aqueduct, which brought water from the foot of the hills to Caesarea. This aqueduct crosses the whole width of the coastal plain. The gradual conversion of the plain's lower parts into bog becomes clear from the evidence of the progressive subsidence of the aqueduct's big arches adduced in Prof. A. Reifenberg's article in this issue. This also demonstrates the limited bearing capacity and rheological properties of alluvial soil (Pl. xi).

C. MATERIAL DERIVED FROM THE COAST AND COASTAL CURRENTS

The same aqueduct has served to check the supposed vertical movement of the shore in relation to its hinterland. The hydraulic gradient of this aqueduct was found to be only about 1:10,000. The height-difference between the point where the acqueduct leaves the mountains and that where it reaches the shore can, therefore, never have been less. If therefore this difference was only a few centimetres at the time of the acqueduct's construction, any subsidence of the shore line could, at the most, have been a few hundredths of a millimetre annually during the last two millennia.

The subsidence theory has been used by some to explain the peculiar sand distribution and beach-erosion phenomena along the coast. According to this theory continuous submergence is the cause of the abrasion which is the predominant process on the coast north of Tel-Aviv. Emergence of the coast south from Tel-Aviv to the Suez Canal is made responsible for the fact that this part of the coast has the character of an 'Anschwemmungs-Küste'. The Nile Delta itself, however, is known to *sink* isostatically under the weight of accumulating sediments.

With the vertical movement theory thus disproved, the observed differences of sand-distribution and erosion have had to be re-interpreted. They have been found to be the result of a supply and transport mechanism along the beaches, which was investigated subsequently.

All the dune sands originate at the beach. Neither rivers nor wind supply additional material, but occasionally they re-mobilize previously deposited material. Matter carried down from the hills is of an entirely different composition from that of the material which causes the sanding-up of the river mouths and makes up the dunes. It consists of flint grains instead of quartz grains, calcite grains instead of aragonite grains and hardly any iron ores like magnetite or hornblende.[1] The wind is very active in producing sand by digging out bowls and creating blow-outs, but it is only able to do so when it is already charged with sand grains in suspension. The prevailing wind direction shows that these katalyzing sand grains are invariably picked up from the shore, where they are continuously being supplied by the surf.

The local production of sand by the surf is shown in the northern parts of the coast by the increased presence of such mineral components in the sand as are typical of the local raw material: Tables B and C show the percentage of $CaCO_3$ (fragments of shells) to increase as we go north.

[1] This mineralogical argument does not hold with regard to the Nile sediments, once supposed to be the origin of the invading sand of Palestine. On purely quantitative consideration, however, it is clear, that the Nile cannot be a continuous supplier today, because the suspended matter at Cairo contains only 0.2% of coarse sand. Even this dwindling amount is sure to settle while the river is making its way through the flat delta.

Locality Km. S.W. of Rafah	Textural Composition								% of Heavy Minerals		
	2—0.75 mm.	0.75—0.3 mm.	0.3—0.175 mm.	0.175—0.15 mm.	0.15—0.075 mm.	0.075—0.02 mm.	0.02 mm.	Salts	0.75—0.3 mm.	0.3—0.15 mm.	0.15 mm.
Rafah	0	2	19	15	35	18	12	Tr	0	4	5.5
10	0	5½	25	11	34	17½	7	0	0	4	5
19	½	8	23	17½	32½	13½	4	0			
29	0	4½	16½	10	50	10	9	0			3.5
38	0	12	24½	5	38	14	3	0	0	1.5	3
48	0	16	25	9½	28	12	5½	1½	0	2	3
57	1	19½	29	10	26	9	3	2			
67	0	14½	— 31	—	36	13½	4½	0			
76	0	25	27½	13	25	6	1	0	0	2.1	2.4
87	0	17	— 39	—	29½	13	1½	0			
96	0	6	19	10	48	13	2	0			
106	1	28	29	8½	28½	3	1½	6			
115	½	25	28	12½	25½	7	½	0	0	1	2
125	½	17	31	8½	30½	18½	2½	0			
134	6½	40	26	9	15	3	½	0	0	1	2
138	1	29	— 40	—	25	2	2	0			
153	½	28	— 45	—	23½	3	0	0	0.5	0.5	0.5
163	0	49	24	7	7	1½	Tr	0			
172	9½	53	20	7½	7½	2	Tr	0			
182	4	51½	16	3	7	1	Tr	0	Tr	Tr	Tr
191	5	45	— 14½	—	31	4	Tr	0	0	0.2	0.2
Kantara	2	59	4½	½	1½		0	0			

Table A

Beyond Naharia dolomitic material preponderates, and at a point where basaltic rocks reach into the sea—at Banyas in Syria—black sand containing grains of volcanic glass abounds.

On the other hand, the flux rates of the sand on the land quite often stand in inverse relation to the local surf erosion rate. This fact and the uniformity of the sands of the central and southern beaches prove the existence of the lateral coastal distribution agency.

By the systematic analysis of the beach material along the smooth and

undisturbed southern stretch, a strong and significant texture-gradient has been found to exist from the Suez Canal to the Israel border (Table A). This points to a continuous removal of material from this sand reservoir and its transport in a northward direction. The transporting agency was found to consist of two essentially independent long-shore currents, which by their concerted action effect the coastal shift. One of them is the bulky coastal current, which flows in an anti-clockwise direction around the Mediterranean as a result of barometric conditions. The other is a strong littoral current, caused by waves breaking at an angle to the shore line. (The velocity of a littoral current is proportional to $W \cdot \sin a$, if W denotes the velocity of the incoming wave-crests and a the angle they make with the shore line.) The magnitude of these currents has been demonstrated by chemical contamination of sea water at one spot and subsequent analysis of sea water samples north of it. Sediment is carried northwards from the river mouths and can be followed for hundreds of metres on aerial photographs. The carriage of sand at various spots off the coast has been estimated quantitatively by suspending pipes with closed bottoms vertically in the water, where they were found to collect up to a centimetre of sediment daily. The total effect, however, becomes manifest when the whole sand stream is being interfered with by natural or artificial obstacles, and when land- and time-marks make the reaction observable.

Such an instance is provided by the colossal moles built by Herod the Great at Caesarea and described by Flavius Josephus. Because of their size they obviously had to influence the pattern of the long-shore current and its sand-carrying capacity. They indeed caused the sand to be thrown upon the beach at such a high rate as to cause a special remark by Josephus. Subsequently the whole Jewish city south of the harbour installations became buried. The sands were picked up by the constant breezes and blown landwards at the same rate as they were deposited by the sea on the beach. This was apparently also the fate of the famous Philistine harbour towns, whose remnants can sometimes be discerned on aerial photographs by the imprint they left on the dune pattern. It is said that only a few decades ago ruins were visible sticking out of the sand west of Gaza.

Locality Km. S.W. of Rafah	% $CaCO_3$					Magnetite, %	Grain count of the heavy fraction 0.15—0.3 mm.										
	Total	0.3—0.15 mm.	0.15—0.075 mm.	0.075—0.02 mm.	< 0.02 mm.		Opaque	Hornblende	Augite	Epidote	Staurolite	Titanite	Rutile	Garnet	Zirkon	Kyanite	Tourmaline	Hypersthene
Rafah		Tr	0.1	1.6	5.5	3.5	41	14	15	13	0	1	6	5	6	0	0	0
10		Tr	Tr	1.3	1.8	0	50	16	30	11	1	0	3	3	2	1	0	0
19	3.0						48	12	10	18	1	0	1	2	7	0	1	0
29				1.5	1.7	4	41	14	14	17	0	0	6	4	3	1	0	0
38	1.8						42	18	13	10	0	0	7	4	6	0	0	0
48			Tr	2.2	7.8		56	8	9	16	0	0	1	10	0	0	0	0
57	1.0						46	15	12	13	0	0	5	3	5	0	1	0
67			Tr	0.1	0.7	3.3	44	12	11	9	1	8	6	8	0	0	0	1
76	1.0					3.3	45	16	14	11	0	0	7	3	3	0	1	0
87			Tr	0.1	0.2		27	14	15	15	2	0	6	5	2	0	2	2
96		Tr	Tr	0.1	0.2		31	18	18	16	0	0	6	6	5	0	0	0
106					1.1	2.0	29	17	18	16	0	1	6	5	6	1	1	0
115		Tr	Tr															
125				0.3	0.6		33	15	14	13	0	2	7	9	5	1	0	1
134							49	21	12	7	0	2	3	3	2	0	1	0
138	0.5					2.0	40	19	15	14	0	1	4	4	3	0	0	0
153	0.5						31	20	18	14	0	1	6	5	4	0	1	0
163					0.2		22	22	10	20	1	0	4	7	7	0	1	0
172					0.4	0.6	32	17	16	17	1	0	8	6	3	0	0	0
182	0.6																	
191	1.3						40	17	12	14	0	0	6	6	4	0	0	0
Kantara				Tr	0													

Table B

The amount of mobile sand found at a particular place has been used to date certain happenings on the shore line. From the present rate of supply it can be deduced that the dune enclave at Caesarea, forming a half circle several kilometres wide with the harbour as its center point, must be mainly a consequence of Herod's enterprise nearly two thousand years ago.

After having dropped their load to the south of the obstacle and having passed it, the long-shore currents are seen to be re-charging themselves

with material by violent shore erosion immediately to the north of it. This inroad of the sea north of Caesarea's harbour happens to be measurable, as the high level aqueduct already described acts again as a landmark. It has been undermined here by the waves, and washed away together with the massive Kurkar rocks on which it was built. Since the rocks have been eroded for about fifty metres behind it, and since the breach is several hundred metres long, the coast must have furnished at least half a million tons of material.

At this particularly bad place sand has been produced from sandstone at a rate of one ton per linear metre per year. Assuming the average sand production rate by erosion to be only a small fraction of this figure, this may be compared with the sand flux rate across the beach, which is several tons per metre per year. It therefore becomes evident that only a small part of the sand is being produced locally, whereas a much greater proportion must be derived from the most southern section of the shore, i.e. from Sinai. Most of the sand travelling north seems to be intercepted by the cliffs and the harbour at Jaffa. It is possible that maritime installations at a southern point of Israel would cut off most of the sand supply for the extensive dune area south of Jaffa. In this way the primary condition for reclaiming any sand area could be created.

Recesses in the coast line such as bays and river-mouths also interrupt the coastal sand shift and cause a sanding-up similar to the effect of protrusions. In the case of recesses the usual tendency is to encourage deposition on the northern side and erosion on the southern. It can be seen that the rivers entering the dune area are being deflected southwards in a characteristic manner.

There is ample evidence that the coastal shift is a three-dimensional effect involving sand suspension, and not, as is sometimes stated, a mere case of sand being pushed along the beach by the waves. The seemingly paradoxical upward movement of sand and other material from the submerged parts of the beach onto the shore seems also to be partly due to a suspensional process. Many researches have been carried out to investigate the mechanism of beach lift and to find an absolute criterium of when to

Locality	% $CaCO_3$	Grain count of the heavy fraction 0.15—0.3 mm.										
		Opaque	Hornblende	Augite	Epidote	Staurolite	Titanite	Rutile	Garnet	Zirkon	Kyanite	Tourmaline
Alexandria	2	32	26	19	17		2		2	2	1	
Suez	0.4	50	12	8	10		2	6	3	7	1	1
Rafah	7	42	15	15	13	1	1	3	2	2	2	1
Khan Yunis	2	38	19	17	16	11	1	3	3	2	1	0
Gaza	0.3	60	12	9	11		2	1	3	2		
Wadi Yibtah	0.7	52	16	9	14			2	3	2	1	1
Ashkelon	6	41	19	20	17	1			1		1	
Bat Yam	9	35	25	17	17		1	1	3	1		
Rishon le Zion	8.5	27	27	23	20			2	2	1		
Kfar Vitkin	5.6	45	24	5	14		1	3	3	4	1	
Hadera	7.2	30	40	5	15		3	2	3	1		1
Caesarea	13	40	27	12	9		2	2	2	4		2
Tantura	13.5	35	25	15	17		1	1	2	2	1	1
Qiriath Motzkin	22	42	33	8	8		1	3	1	3	1	
Naharia	93	50	17	10	16		1		4	1		1

Table C

expect a downward movement of material on the beach and when an upward movement. An underwater observatory was built by Zenkovitch at the Crimean beach and small-scale laboratory models were employed by R. A. Bagnold. By both methods the existence of an erosion-deposition cycle of a period of approximately 50 years was shown to be likely in the case of beaches in equilibrium.

D. THE LIFTING AND DISTRIBUTION OF SAND AND DUST BY THE WIND

The actual lifting force, is, of course, not the lateral movement of the medium, either wind or sea water. Lifting is intrinsically connected with the turbulence of the medium only. Turbulence enables a fluid to take specifically heavier particles into suspension and allows them thereby to reach higher levels at the expense of undirected kinetic energy.

The atmosphere is predisposed to effect lift and transport material

on a much wider scale than coastal currents, which after all are confined to activity along defined lines. Bare, arid areas will, on the whole, keep up a certain equilibrium with material kept in suspension in the turbulent atmosphere, at which the average rate of erosion equals the rate of deposition within the area. Wet areas, however, and those with a covering of vegetation, cause deposition to take place irreversibly. Even with irregular wind directions an overall movement of material from desert areas into sown land, irrespective of relative levels, is therefore to be expected. In general, a continuous transference of dust and soil material will take place to points of less turbulence.

Preliminary measurements have merely succeeded in showing the irreversible deposition rate of atmospheric dust to be larger than 0.01 mm. annually at Jerusalem. (Estimated by the formula

$$D=\frac{c \cdot v}{d}$$

where D denotes the deposition rate, v the average sedimentation velocity of the dust in calm air, c its concentration and d the density of the sediment.) It is conceivable that the deposition effect may work selectively at certain defined places only, as does wind erosion—its negative aspect—which rather acts upon definite spots and does not attack areas evenly. Thus, for instance, strata some hundred metres deep are supposed by Ball and others to have been removed by the wind in the western desert of Egypt, creating the famous kilometre-wide Qattara depression. In southern Israel too abound such basins, which are characteristically devoid of any drainage outlet. They are a few score metres deep and hundreds of metres wide and are obviously the product of seasonal dust-storms, which derive their dust content from them.

It may generally be stated that wind has an inherent tendency to work against gravity. Where left the choice, it will erode the lower places and deposit on the higher ones, and it will not sweep height differences flat, as might be expected. This tendency is proved by the very existence of sand ripples, sand ridges, dunes, and the huge dust bowls, which are formed and maintained in the face of counter-balancing effects such as the

continuous sandslides on the dune's slip-slopes and the wash-down by rain. The total absence of rain allows these phenomena to reach even geographical size, as in the above-mentioned case of Egypt's depressions. The counter-balancing forces convey a quantitative picture of the magnitude of the wind lift, which is necessarily equal to them. In the case of beaches and coastal dunes the total lift obviously even exceeds the downward movements on the beach slopes.

Our general unfamiliarity with the appearance and extent of anti-gravitational processes in nature (because generally their effects are obliterated by processes proceeding in the direction of gravity) often makes phenomena near beaches appear paradoxical to us. The preponderance of lifting processes sometimes causes the sediments to become sorted according to patterns even less understandable than dune or ripple formation.

Thus Petrbok, for instance, found ruins of a Roman house underneath characteristic accumulations of Pectunculus shells, forming beds near Tel Aviv. Orthodox reasoning forced him to conclude a several metre rise and subsequent fall of the Mediterranean level. There is, however, no other indication that such an event has really taken place. The shells may have been deposited by a moving sand dune since accumulations of shells in such dunes are of frequent occurrence.

Another remarkable phenomenon was met in the area shown on the aerial photograph of Caesarea (Pl. viii/ix): Here a dense carpet is spread over the dune consisting of sherds of pottery and glass, broken implements, sea shells, mosaic *tesserae* of quite uniform size (the size of orange peels if flat, and not more than hazelnut size if compact). Underneath these dunes are the ruins from which these objects must have come. Strangely enough, the small valleys between the dunes, which are nearly level with the houses, are often devoid of such fragments.

Similar peculiar arrangements often occur on the much higher dune tops farther inland, where suddenly sea shells, dead snails, rifle bullets, plant seeds etc. are found to be neatly sorted out in patches on the surface.

In the latter case an explanation may be attempted by assuming the dunes to have formerly been higher. During the process of deflation all

heavier objects held within the mass have become concentrated on the surface.

In general, chronological order of the various strata cannot be taken for granted in the coastal plain. The reason for this is the perpetual tearing up of the deeper layers by the wind as the dunes pass over them. Even when deposition is taking place on the whole the wind keeps on cutting deeply into the dune-valleys, re-burying the material it has removed at definite levels near the dune tops. Caution is advised in reading soil profiles in former dune-areas. It should be kept in mind that several layers of great depth one on top of the other—up to the height of a dune—are being laid down simultaneously while the dunes advance.

The amount eroded between the dunes e, the amount supplied over the top of a dune s, the amount being lifted and sliding down the dune's slip-slope l, all in unity time, are related to the velocity of advance of the dune (identical to the velocity of its slip-slope) v, its height H and its width W by the formulae

$$s-e=v \cdot H \cdot W \qquad s+e=l \text{ (if } H \text{ const.)}.$$

Theoretically, v can even be negative and should not be confused with the velocity of encroachment C, which is always positive.[2] C is connected with the overall flux of sand per unity front length $\bar{F}$, by

$$C=F \cdot H.$$

The average change of height $d\bar{H}$, which measures the rate of deposition or deflation respectively, is then given by

$$d\bar{H}=dC-d\bar{F}.$$

While s, e and l are easily inferred from measurements by means of ditches and sand-traps and from v, it is much harder to measure $\bar{F}$, $d\bar{H}$ and C. Opportunity to estimate approximately the values of these basic concepts was again found in the Caesarea area. The two aqueducts, running for three kilometres parallel with the shore, form a line of reference for the estimation of the amount of sand which has crossed the beach. A reference

[2] Where H is large, both v and C will be small. Egyptian fellahin in the depressions are said to sow their fields in the wind-shadows of very large dunes for protection from sand.

line on the other end of the wind-drive was provided by the Benyamina-Pardess Hannah railway track, with its encroaching sand dunes.

The estimate along the railway track gave the sand flux as about seven tons per annum on a metre front. This estimate may be considered as a representative average value, since the row of eucalyptus trees planted there twenty years ago does not interfere with the sand movement very seriously. The estimate on the shore line giving a figure of the same magnitude must, however, be considered to be unrepresentatively small, because of the especially adverse conditions which hampered sand movement there.

(The latter value was deducted from the number of years that were necessary for the sand to surmount and pass a continuous vertical barrier nine metres high on the beach, and to climb another one of six metre height close beyond it. The two barriers were formed by the Caesarean aqueducts and the date at which the sand encroached on the second one could be deducted from the fact that a roof had to be added to it for protection. The mortar used for this job indicates that at that time a period of 600 years had elapsed since the completion of the first aqueduct.)

Comparison of the two sand flux data at the two extreme points of the sand-drive leads to the conclusion that deposition is taking place between these two points. Because of the heterogeneity of the field, this cannot be measured directly, but is confirmed by the frequent burial of triangulation points and by other direct observations. A row of concrete poles that crosses the whole width of the dune area at Mikhmoret (near Hadera) indicates an overall heightening of the order of several millimetres per year. Along some stretches the fence has been covered more than a metre deep by the sand; while along others an almost equal amount has been removed from beneath the poles. These alternations, corresponding to several dune waves, might be connected with the existence of a cycle. The latter, however, cannot be expected to display here its full *habitus*, because of the somewhat limited area. Such periodic phenomena are, according to H. T. U. Smith, possibly caused by biological factors.

E. SUMMARY AND CONCLUSION

Accumulation of sand and soil material in the coastal plain of Israel is to be divided into two categories: material washed down from the hills and that thrown onto the beach after lateral transport by long-shore currents.

In both cases, the average rate of the influx of material has been estimated to be of the order of about ten tons per metre front annually. This causes an average annual rise of the sediment level of one millimetre at least. The rate of local sand production by beach erosion was shown to be only a small fraction of the amount delivered annually upon the plain. The greater part of the invading sand was consequently brought from the south-west by coastal currents. The far northern section of the coast is not being reached by this supply, and $CaCO_3$ derived from biological sources and other local material becomes more and more predominant in the sand.

The texture-gradient, revealed by analysis of sand samples taken along the Sinai beaches, shows that the material perpetually transported in a northward direction by the coastal currents, is being drawn from these beaches.

To make the reclamation of Israel's sand dune areas possible, the further movement of sand must be stopped as close as possible to its source. Starting from these places sand-stabilization can then proceed. If the sand cannot be intercepted on its way along the coast, it should be prevented from being deposited on the beach and from being picked up by the wind. Deposition of sand on the beach and increased shore erosion has been shown to be the consequence of disturbances of the shore line and to have often been caused by maritime installations. Efforts to stabilize the wind-driven sand within the dune belt or even along its outer fringe—as tried on one occasion by PICA—are unlikely to succeed so long as the above-mentioned primary conditions are not fulfilled.

Being unfamiliar with anti-gravitational movements and sorting phenomena, we are prone to mistakes when interpreting geomorphological phenomena near beaches. Caution is advised in basing archaeological chronology on sorted objects such as artifacts, potsherds or shells found embedded in coastal formations.

BIBLIOGRAPHY

Adler, A.: *Zur Morphologie der Küste von Palästina.* Dissertation, Universität Jena. Erfurt, 1934.

Bagnold, R. A.: The Movement of Desert Sand. *Proc. Royal Soc.*, A 157, 1936, pp. 594-620.

Bagnold, R. A.: Sand Movements by Waves: some small-scale experiments with sand of very low density. *Journ. Institut. Civil Engin.*, 27, 1947, pp. 447-459.

Ball, J.: Problems of the Libyan Desert. *Geogr. Journ.*, 70, 1927, pp. 21-38.

Brawer, A. Y.: Chemical Analyses of Sand Samples from the Palestinian Coast. *Zionist Executive, Dept. of Trade & Industry, Economic Data,* No. 9. 1923.

Chepil, W. S.: The Translocating and Abrasive Action of the Wind. *Soil Science,* 61, 1945, p. 167.

Chepil, W. S. & Milne, M.: Wind Erosion in Relation to Size and Nature of the Eroded Area. *Science of Agric.*, 21, 1941, p. 479.

Cornish, V.: On Desert Sand-Dunes bordering the Nile Delta, *Geogr. Journ.*, 15, 1900, pp. 1-32.

Dalman, G.: Die Küstenflüsse Palästinas südlich von Caesarea. *Zeitschr. Deutsch. Paläst. Ver.*, 37, 1914, pp. 338-348.

Floyer, E. A.: Description of Sand Dunes between El Kantara and El Arish. *Geogr. Journ.*, 11, 1898, pp. 559-563.

Gaillard, D. D.: *Wave Action in Relation to Engineering Structures.* The Engineers School, Fort Belvoir, Va., 1935.

Garrod, D. A. E. & Gardner, E. W.: Pleistocene Coastal Deposits in Palestine. *Nature,* 135, 1935, p. 908.

Gerhardt, P.: *Handbuch des Deutschen Dünenbaus.* Berlin, 1900.

Guest, A. R.: Itinerary from Kantara to El Arish. *Geogr. Journ.*, 13, 1899, pp. 281-285.

Guthe, H.: Die Landenge von Suez im Altertum. *Zeitschr. Deutsch. Paläst. Ver.*, 50, 1927, pp. 67-92.

Haefeli, L.: *Caesarea am Meer, Topographie und Geschichte der Stadt nach Josephus und Apostelgeschichte.* Münster, 1923.

Hall, W. C.: *A Model Study of Beach Erosion.* M. Sc. Thesis, Univ. of California, Dept. of Engin., 1938.

Hull, E.: Sanddunes of Palestine and Philistia. *Geogr. Journ.*, 9, 1897, p. 303.

Lapsley, W. W.: *Sand Movement and Beach Erosion.* M. Sc. Thesis, Univ. of California, Dept. of Engin., 1937.

Loewengart, S.: Zur Geologie der Küstenebene Palästinas. *Zentralblatt f. Min. Geol. Palaeont., Abt. B,* 1928, pp. 498-519.

Meyer, M. A.: *History of the City of Gaza.* Thesis, Columbia Univ., New York, 1907.

Moon, F. W. & Sadek, H.: *Topography and Geology of Northern Sinai.* Petrol. Res. Bull., 10. Cairo, 1921.

Oliver, F. W.: *Some Remarks on Desert Duststorms.* Alexandria, 1942.

Oosting, H. J. & Billings, W. D.: Factors Effecting Vegetational Zonation on Coastal Dunes. *Ecology,* 23, 1942, pp. 131-142.

Picard, L. & Avnimelech, M.: On the Geology of the Central Coastal Plain. *Journ. Palest. Orient. Soc.,* 17, 1937, pp. 255-299.

Range, P.: *Die Küstenebene Palästinas.* Ges. f. Palästinaforschung 8, Berlin, 1922.

Range, P.: Die Isthmuswüste. *Zeitschr. Ges. f. Erdkunde Berlin,* 1921, pp. 196-215. Ref. p. 203.

Range, P.: Wissenschaftliche Ergebnisse einer geologischen Forschungsreise nach Palästina im Frühjahr 1928. *Zeitschr. Deutsch. Paläst. Ver.,* 55, 1932, pp. 42-74.

Reifenberg, A.: *The Soils of Palestine.* London, 2nd ed., 1947.

Rim, M.: *Sand Dune Movement and Formation of Red Sandy Soils in Palestine.* Thesis, Jerusalem, 1949.

Sachsse, E.: Die römische Strasse durch die Sinaihalbinsel nach der Peutinger'schen Tafel. *Zeitschr. Deutsch. Paläst. Ver.,* 51, 1928, pp. 265-268.

Simaika, Y. M.: *The Suspended Matter in the Nile.* Cairo, 1940.

Shalem, N.: Considerazioni sull'origine della sabbie palestinesi da Ras-en-Nakura al confine egiziano. *Atti Società Naturalisti & Matematici di Modena,* Ser. 6 v. 7 (59), 1928, p. 47.

Smith, H. T. U.: Sand Dune Cycle in Western Kansas. *Bull. Geol. Soc. Amer.,* 50, 1939, p. 1934.

Stark, K. B.: *Gaza und die Philistäische Küste.* Jena, 1852.

Vroman, J.: *The Petrology of Sandy Sediments of Palestine.* Bull. Geol. Dept. Hebr. Univ. Jerusalem, 5, 1. 1944.

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A Jewish Sepulchral Inscription from Caesarea Palestinae*

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SOME time ago a fragment of an inscription (Pl. xv, Fig. 11) was found in the grounds of Sdot-Yam, a collective settlement, situated south of Caesarea Palestinae outside the Herodian city wall. On that fragment are represented a *menorah*, a *lulav*, and a *shofar*, by which it is easily recognizable as Jewish. In view of the comparative scarcity of Jewish inscriptions from Caesarea[1] every fragment is of especial importance. The inscription is carved in monumental, carefully executed letters on a white marble slab, the writing surface being divided by horizontal lines. The stone is broken on all sides; in the lower part very little is missing; its height is 15 cm., the maximum width is 10.3 cm., and it is 3.2 cm. thick; the height of the letters is 3 cm. The following remnants of letters are discernible:

⌣
YM/
AM8
XANI

Any attempt at restoration must take into account the fact that the seven-branched candlestick with the two other Jewish liturgical symbols

* My thanks are due to the Department of Antiquities of the Government of Israel, for permission to publish this inscription, and to Mr. Aron Wegmann of Sdot-Yam, who found and photographed it.

[1] Or such as concern persons of Caesarea. In *Sepher ha-Yishuv* I, ed. by S. Klein (1939), I was able to adduce only 8 (see *ib.* p. 150/1 and 179). A ninth is now added. All of them are apparently sepulchral inscriptions. Three inscriptions from a synagogue have been published by me in the *Alexander Marx Jubilee Volume*, Hebrew Section, Jewish Theological Seminary, New York, 1950, pp. 433-449.

(deliberately, as it seems, placed near it), occupy the middle of the writing surface, of the width of the stone, and of the line.

Thereby the approximate length of the line is given. Considering the names and formulas of the hitherto known Jewish inscriptions from Caesarea, the restoration may be as follows:

1 μημ]ό[ριον
2 Σ]υμά[χου τοῦ
3 υἱοῦ Σ]αμου[ὴλ
4 μη]χανι[κοῦ

Line 1: The remnant of the letter can hardly be anything else but the lower part of *O*. Two of the Jewish inscriptions found at Caesarea begin with the very common designation of a tomb μημόριον.[2] This would give the approximate length of the line. The writing in the lost line must have been well spaced since the *O* stood fairly far to the right.

Line 2: contained the name of the deceased. No other restoration than that proposed is possible. The Greek Σύμμαχος with a double μ has in the Hebrew transliteration one *mem* only. The name is very common in the Hellenistic East in papyri and inscriptions. The author of the fourth column in Origen's Hexapla, who lived under Marcus Aurelius, bore this name.[3] It was also the name of one of the Tannaites.[4] Two Jewish Σύμμαχοι are known from inscriptions in Rome.[5] A Jew Σύμαχος Ἰούστου—the spelling of the name is the same as in our inscription—was buried in Tiberias.[6] Yet another Jew Symmachos appears in an inscription from Jaffa.[7] The name of the deceased follows the designation of the tomb

[2] Cf. *Sepher ha-Yishuv*, p. 150, Nos. 68, 69. No. 67 begins with μνῆμα Λήας.

[3] That Symmachus, the translator of the Bible, was a member of the sect of Ebionites or a Samaritan, and was converted to Judaism, seems to be certain. Whether this was his Jewish name, assumed upon his conversion to Judaism, or his former name, cannot be determined. Such a meaningful name might be conceived as Jewish.

[4] He is סומכוס בן מאיר-Symmachus son of R. Meir, cf. S. Krauss, *Gr. u. Lat. Lehnwörter im Talmud*, p. 376 s. v.; see *ibid.* the note by Loew; he refers to Geiger, who would identify him with the translator of the Bible.

[5] Cf. Frey, *Corp. Inscr. Jud.* I, Nos. 408, 409.

[6] Cf. my article in the *Sepher Jochanan Lewy* (Jochanan Lewy Memorial Studies), p. 200 foll., 'Contributions to the History of Tiberias, an Epigraphic Study', p. 222, No. 8.

[7] Cf. *Sepher ha-Yishuv*, p. 87, No. 57.

without the article, just as in two other Jewish sepulchral inscriptions from Caesarea.[8]

Line 2/3 : Since the restoration Σ]αμου[ήλου or Σ]αμου[ήλ seems to be certain, we must assume the words τοῦ υἱοῦ before the fathers name, according to the Jewish inscription from Caesarea μνῆμα Λήα(ς)[τῆ]ς θυγατρὸς [Βεν]ιαμίν.[9] The question of division of the words τοῦ υἱοῦ is solved if we assume that both the ου were written in a ligature as in C]αμ[ήλ, and similary in C]υμά[χ. In that case line 2 would contain eight letters and line 3 nine.[10] Samuel is one of the commonest Jewish names in the Talmudic period. In Beth She'arim it holds the third place.[11]

Line 4: All the letters are perfectly clear. The last is by no means the left shaft of an *H,* but is clearly an *I.* Since the distribution of the letters in the available space is fairly careful, it is unlikely that in *XANI* we have the end of the inscription. The symmetrical disposition of letters about the middle line indicated by the *menorah* justifies the assumption that also in line 4 the text reached the end of the line.[12] The proposed μη]χανι[κοῦ meets all requirements, but, so far as I can see, there is yet no evidence for it in Palestinian inscriptions. It appears once in Plutarch in the sense of siege engineer,[13] and in the papyri it has the meaning of mechanic or technician.[14] And, especially as an adjective, it occurs in connection with

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[8] They begin *(Sepher ha-Yishuv,* p. 150, No. 68) μημόριον Μεγάλου and No. 67 μνῆμα Λήας. No. 69 reads μημόριον διαφέρων and is here irrelevant.-The missing Σ must have been fairly wide, as before the *O,* the remnants of which survive in line 1, three letters must be supplemented. It may have been one with sharp edges. Cf. the wide *X* in line 4. The stone mason may thus have emphasized the name of the deceased.

[9] Cf. *Sepher ha-Yishuv,* p. 150, No. 67. In No. 68 μημόριον Μεγάλου Βαβυλωναρίου υἱοῦ Ζερέκα the article τοῦ is missing and is not necessary since the trade designation precedes the word υἱοῦ. For further information about this inscription see *Bull. Jew. Palest. Expl. Soc.,* 2, 1934, pp. 56-57.

[10] It is of course not precluded that Σαμουήλου was written and thus the line contained 10 letters, as, for instance, in the inscription from Caesarea, see *Sepher ha-Yishuv,* p. 150, No. 66: τέκνα Σαμουήλου.

[11] *Bull. Jew. Palest. Explor. Soc.,* 5, 1937, p. 81.

[12] It is hard to think of a word ending in χανι. Besides, the free space after *I* seems to be somewhat too large. But also before *Y* in line 2 there is a similarly large space.

[13] Pericles 27, where he speaks of the siege of Samos by the Athenians.

[14] See Preisigke *Wörterbuch* s. v. and also under μηχανάριος.

water works.[15] We know a certain 'Απολλώνιος μηχανικός[16] and a man who is ἀρχιμηχανικός.[17] A tombstone in Bubastis mentions a certain 'Ηρώιδης μηχανικός.[18] Whether he was concerned with water works cannot be ascertained. In Egypt the μηχανή—the *saqiyya* operated by a beast of burden—was so common that even the irrigated land was later called μηχανή.

For the usage of μηχανή in the sense of water installation in Palestine there is so far only epigraphic evidence. I mean the inscription from South Palestine which reads: Καί ταύτην τὴν/τῆς τ(ῶν) ὑδάτων μεχαν/ῆς ὁ λαμπρ(ότατος) πατὴρ 'Ιλ/αρίων ἐφεῦρεν/ἀρετήν.[19]

That water installations are meant is shown both by the inscription itself (ὑδάτων) and by the semi-circular opening ⊃ in the middle of the last two lines, where there was the end of the pipe from which the water flowed. This installation—as is suggested by καὶ—might have been a part of another, perhaps more extensive, installation. In Palestine, it is true, this inscription is evidence for the existence of μηχανή only in the 6th cent., but even here the usage of the term is certainly older. Since the remnants of the letters do not seem to admit of any other restoration, we may certainly think in the first place of a water works technician functioning at Caesarea, although of course it is not precluded that he was a technician of some other kind. The great aqueduct in the north of the city shows at its present southern end pipes branching off eastwards, which

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[15] Cf. *ibid.* esp. s. v. μηχανάριος and M. Schnebel, *Die Landwirtschaft im hellenistichen Ägypten* (München 1925) I, p. 69-84.

[16] Preisigke *Sammelbuch griech. Urkunden aus Ägypten*, No. 219 (=1109, see Preisigke, *Wörterbuch* s. v.). According to Preisigke, *Sammelb.* ad. nos. 1108-1111 the graffito belongs to a group inscribed at the Nilometer in El-Hosh near Silsilis. Possibly this Apollonius was a water supply technician.

[17] Cf. Preisigke *Sammelb.* No. 1113. The inscription reads: L ια' 'Αντωνίνος. / 'Απολλῶς Πετε[πα]χούμιος / ἀρχιμηχανικ[ός]. It is from the same place as No. 1109. It is dated from the year 147/8 A.D. Is this Apollos identical with Apollonius and do we see thus two stages of his career?

[18] *Ib.*, No. 310.

[19] I have published it in *Bull. Jew. Palest. Explor. Soc.*, 9, 1942, pp. 89-93: 'A Greek Inscription on a Water Supply Installation from Southern Palestine'.

may have served for irrigation purposes. The existence of other irrigation installations east of Caesarea is also probable.

The period when this Symmachus, son of Samuel, lived can only be determined by means of palaeographical data. Unfortunately there are too few characteristic letters preserved to attempt a definite determination. The ligature of o and υ is attestable even in the Roman period, but it is especially frequent in Byzantine times. If the forms of script are compared with those from Gerasa[20] there appear to be two alternatives: either the 3rd or the 5th-6th century A.D. But to which of these two periods the inscription should be attributed, I would not venture to decide.

[20] Cf. C. B. Welles in Kraeling, *Gerasa*, pp. 359-367. There is no other dated collection of alphabets of Palestinian inscriptions.

The Development of the Roman Road System in Palestine

M. AVI-YONAH

THE general outlines of the network of roads in the Roman provinces of Judaea or Syria Palaestina and Arabia are fairly well known. A reliable summary has been published by P. Thomsen in 1917[1] and later discoveries have modified only details.[2] The chronological development of the roads has, however, been sketched only once.[3] It might be worth while, therefore, to reconsider it briefly.

The inscriptions on the milestones are, as far as they are preserved, our principal sources for this purpose. The preservation of milestones has, however, been necessarily accidental, and the preservation of a legible inscription has been still more fortuitous. We must therefore eke out the evidence of the milestones from general historical knowledge and from certain logical considerations: thus it is unlikely that any Roman legionary camp would be left without a road-connection; nor would a length of road be left 'hung up in the air', unconnected with the general network existing at the period of its construction.

The oldest Roman road in Palestine is undoubtedly that which followed the coast. Its northern sector, from Antioch to Ptolemais (Acre)[4], was cer-

[1] Thomsen, P.: Die römischen Meilensteine der Provinzen Syria, Arabia und Palaestina. *Zeitschr. Deutsch. Paläst. Ver.*, 40, 1917, pp. 1-103; supplemented by M. Avi-Yonah, *Map of Roman Palestine*, 2nd ed., 1940, and F. M. Abel, *Géographie de la Palestine*, II, 1938, pp. 222-231. [2] Cf. *Quart. Dept. Antiq. Palest.*, 12, 1946, pp. 96-102.

[3] Kuhl and Meinhold, *Palästinajahrbuch*, 24, 1928, pp. 118 ff.

[4] (Nero Cl)audius (Caesar Au)gustus ... (tribunicia potestate) bis ... (viam?) ab Antiochia (munivit? ad n)ovam colon(ia)m (Ptolemai)da. Thomsen, *op. cit.* No. 922, p. 18; cf. also A. Alt, *Zeitschr. Deutsch. Paläst. Ver.*, 51, 1928, pp. 253 ff. An inscription erected by the inhabitants of Ptolemais and the neighbouring villages in honour of Nero was found at Naharia, 17 kms. N. of Acre, *Quart. Dept. Antiq. Palest.* 12, 1946, pp. 85 ff., No. 2.

tainly constructed in the early days of Nero. South of Acre the only milestones found so far are dated to A.D. 210 and 217; the extant fragments do not, however, mention the construction of a road and most likely they commemorate repairs only. In the coastal plain few milestones survive and we should not treat the absence of earlier stones as a conclusive argument. It is far more likely that this important road (linking as it does the two great military bases of Alexandria in Egypt and Antioch in Syria) was completed either during the First Jewish Revolt or immediately afterwards. The march of Titus from Alexandria to Caesarea early in A.D. 70 might either have been on the new road or it might have served to fix its route. The presence of road-surveyors with the army of Vespasian is attested by Josephus.[5]

The fall of Jerusalem was followed by the establishment of a legionary camp on its ruins, held by the Legio X Fretensis. By an anomalous arrangement the civil headquarters of the newly-created 'Provincia Judaea' were not transferred to the garrison camp, but left at Caesarea, the seat of the former procurator of Judaea. A direct road linking the administrative and military headquarters of the province would naturally be required in these circumstances. The shortest line between Caesarea and Jerusalem passes Antipatris-Thimna and Gophna.[6] The milestone of Nerva found at Sha'fat three miles north of Jerusalem should obviously be assigned to this road;[7] but owing to the fact that the first fifteen miles of the road from Jerusalem to Neapolis coincide, it has been erroneously assigned to the latter.[8] Four other milestones have been found on this road near Gophna and beyond, but on none of them was the date decipherable.[9]

At the same time another road was made connecting Scythopolis (Beth-Shean) with Pella and Gerasa. This road had to be repaired under Trajan,[10] hence its original construction must have been of an earlier date.

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[5] Josephus, *BJ*, III, 6, 2 = 118; *ib.*, IV, 5 = 649-663.

[6] Thomsen, *op. cit.* (supra, n. 1): Road XXXVI, p. 76.

[7] *Ib.*, No. 263, p. 75: Imp. Nerv(a) Aug. pont. m(ax.) trib. pot. . .

[8] *Ib.*, p. 73 f.

[9] *Ib.*, p. 76, Nos. 267-270.

[10] *Ib.*, p. 65, No. 215: Imp. Caesar . . . Nerva Traianus . . . trib. pot. (X)VI . . . *refecit* per (C. Cla)udium Severum leg. Aug. pr. pr.

We cannot assume that these cities were connected with each other but remained unconnected with the outer world; we must presume therefore that at least one of the roads between Scythopolis and Damascus[11] was made at the same time. We may perhaps assume that the need for these roads arose from the growing economic importance of the Decapolis as well as from the necessity for prompt military assistance in the not unlikely case of another revolt.

In the days of Trajan the annexation of the Nabataean Kingdom (A.D. 106) was followed by the greatest piece of Roman road-making in the Orient, the construction of the *via nova* in the years 111-114. It was the work of Claudius Severus, the first governor of Provincia Arabia, and ran from Bostra to Aila ('Aqaba) on the Red Sea.[12]

At that time, therefore, the Roman roads in Palestine consisted of two separate systems; the coastal road with an extension to Jerusalem, and the Arabian road, connected via Damascus with Scythopolis, Pella and Gerasa. The last named city was indeed transferred to the new province, but remained for the time being without a direct connection with its backbone, the *via nova*. These defects of the road-system were repaired by Hadrian. At the time of his death the network of Roman roads in Palestine had very nearly assumed its final shape.

In the reign of Hadrian there were two main periods of road-building activity, the first associated with the *adventus Augusti* in A.D. 130-1; the other with the revolt of Bar-Kokhba (132-135) and the measures consequent upon it. In 129 the road Scythopolis-Pella-Gerasa was connected with the Arabian road at Philadelphia, probably in prevision of the imperial visit.[13] To the same year or the following we might then tentatively assign the connection Heshbon (on the Arabian road)-Livias-Jericho-Jerusalem.[14] It was probably used by Hadrian on his return from Petra, via Jerusalem. For a continuation of his travels from Jerusalem

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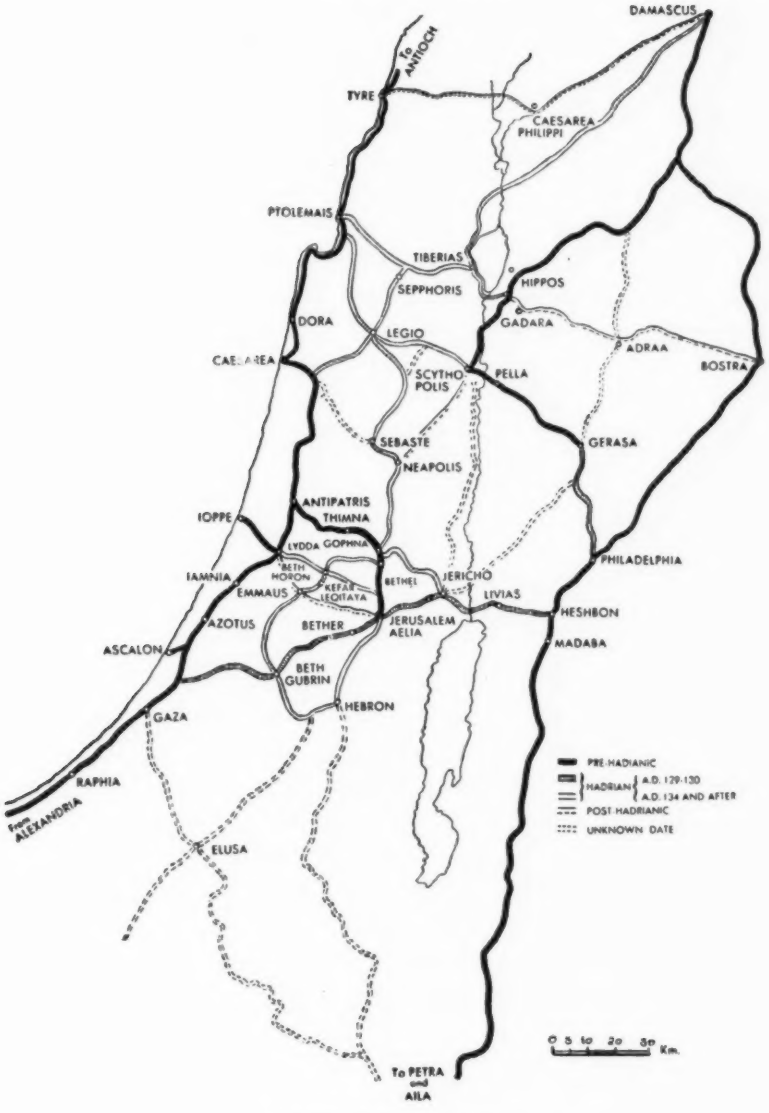
[11] *Ib.*, pp. 33-34, 70-71.

[12] *Ib.*, pp. 34-59, Nos. 67-187.

[13] *Ib.*, p. 64, No. 211a.

[14] *Ib.*, p. 68, No. 230a (of 162) '... pronepotes ... *refecerunt*' i.e. it was already repaired under Marcus Aurelius.



Road Map of Roman Palestine

onwards we have the evidence of a milestone (dated A.D. 130) which was found on the Jerusalem-Gaza road.[15] This line should, therefore, also be related to Hadrian's visit.

Hadrian's visit was followed by the decision to erect a Roman colony, Ælia Capitolina, on the ruins of Jerusalem, and this, in turn, was one of the causes of the revolt of Bar-Kokhba. The Gaza-Jerusalem road, just completed, may very likely have been used by the ill-fated Legio XXII Deioterana which came up from Egypt via Gaza and was lost in the fighting. However, as the war progressed, it must have been most useful for the Roman operations in Judaea from their south-western base. In the third year of the fighting the insurgents were finally confined to a small area in Judaea, west of Jerusalem. It has been suggested that the road connecting Beth Gubrin (later Eleutheropolis) with Hebron might have constituted part of a Roman military line encircling the area in revolt.[16] This line should, however, be extended further northwards in consideration of the Midrashic text which mentions a check of refugees from the war-area carried out by Roman guards stationed at Beth-Horon, Kefar Leqitaya (Beit Liqya) and Emmaus.[17] Recently a fragment of a Roman road was discovered at Beit Jiz, south of Emmaus.[18] It leads southwards and was presumably connected with a known Roman road from the Valley of Sorek to Beth Gubrin. From Emmaus another known road led northwards through Kefar Leqitaya to Beth Horon, and hence to the fourth mile on the road from Jerusalem to the north, thus completing the guard circuit around the insurgent area.

The last named section of this road, viz. that from Beth Horon to the Jerusalem-Gophna road, followed the old 'public way' of Josephus,[19] the main road between the ancient capital and its port at Jaffa. We may assume therefore that the whole of this line, at least from Lydda, was now re-made as a Roman road. It must have been most useful as a link between

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[15] *Ib.*, p. 80, No. 282: Imp. Caesar ... Hadrianus Aug ... trib. pot. XIV,

[16] Kuhl, *Palästinajahrbuch*, 24, 1928, p. 127.

[17] Thr. R., 1, 16, ed. Buber, 416.

[18] Reported by Mr. Kleinmann, Jerusalem.

[19] *BJ*, II, 12,2 = 228.

the Roman bases in the coastal plain and the troops operating north and north-west of Jerusalem.

It is even possible that this road was continued further eastwards from Gophna via Aphairema (et-Taiyibe) to Jericho. It would then by-pass Jerusalem on the north and link the Roman bases in the coastal plain (e.g. Lydda) with those beyond the Jordan (Philadelphia and Gerasa) by the way of the Heshbon-Jericho road built presumably in 130. The only extant milestone of this road may be attributed to Hadrian.[20]

When the revolt of Bar-Kokhba was finally suppressed and Bether had fallen, further political and military changes occurred, which set their mark on the development of the road system of Palestine. The praetorian Province of Judaea now became the consular province of Syria Palaestina; a second legion (Legio VI Ferrata) was stationed at Kefar 'Otnay, thence-forward to be known as Legio (until, under the Arabs, it became Lajjun). The new legionary camp was at once joined by roads (a) south-westwards to Caesarea, the capital of the province, and (b) northwards to Sepphoris, one of the centres of Galilee, which now remained the only purely Jewish region in Palestine and thus a potential centre of danger. The former road crossed the Carmel by way of the Wadi 'Ara pass. It has been well known for some time; a number of milestones were found along its route, although none could be dated.[21] It can be brought into the proper historical sequence when considered in conjunction with its northern continuation Legio-Sepphoris, along which milestones dating to the reign of Hadrian have recently been discovered.[22] Various other roads radiated from the new camp: one to Ptolemais (Acre) established its connection with the coastal road, another to Scythopolis (Beth-Shean) joined it to the roads beyond the Jordan.[23] A third road passed Sebaste, Neapolis and Gophna and connected Legio and Ælia Capitolina, the camps of the two legions now stationed in Palestine. Up to Neapolis it is certainly Hadrianic:[24] its

[20] Thomsen, *op. cit.* (supra, n. 1), p. 76, No. 266, note 1.
[21] *Ib.*, pp. 69-70, Nos. 233-241. [22] *Quart. Dept. Antiq. Palest.*, 12, 1946, p. 96, No. 13.
[23] Thomsen, *op. cit.* p. 69, No. 232; *Quart. Dept. Antiq. Palest.*, 12, 1946, pp. 101-102.
[24] Thomsen, *op. cit.* p. 70, No. 142.

continuation might be assigned on logical grounds to the same scheme but so far the earliest milestone extant is of the year 162.[25] A further 'security road' was built by Hadrian from Ptolemais on the coast via Sepphoris to Tiberias,[26] affording another ready access from the coast to the heart of Galilee.

At the death of Hadrian the main road system was therefore practically complete. Later additions include the roads Damascus-Salcha-Gadara and Ælia Capitolina-Emmaus, both built under Marcus Aurelius;[27] the Bostra-Gerasa road made by Commodus[28] and the short-cut Neapolis-Scythopolis dating to the reign of Septimius Severus.[29] A milestone of Caracalla (unpublished) was recently discovered at Dan on the road from Tyre to Caesarea Philippi (Paneas) and another, anepigraphic one, east of Lake Hule; this may have belonged to an undiscovered road joining Caesarea Philippi and the Jordan bridge at Jisr Banat Ya'qub. The original date of both these roads remains as yet in suspense. No data are available as regards the date of the Scythopolis-Jericho road along the Jordan, or the roads south of Beersheba.

This rapid survey confirms the other evidence in our possession regarding the crucial importance of the reign of Hadrian in general, and the suppression of Bar-Kokhba's revolt in particular, as the turning point in the history of Palestine under Roman rule. This fact is only too often disregarded owing to a large extent to the spectacular account of Josephus. It has turned the attention of scholars to the First Revolt and has made the equally if not more serious war of Bar-Kokhba into another 'Forgotten War'.

[25] *Ib.*, pp. 73-74, No. 259. [26] J. H. Iliffe, *Quart. Dept. Antiq. Palest.*, 2, 1932, p. 120.
[27] Thomsen, *op. cit.* (supra, n. 1), p. 32, No. 66; p. 77, No. 272. [28] *Ib.*, p. 60, No. 189.
[29] *Ib.*, p. 72, No. 254a.

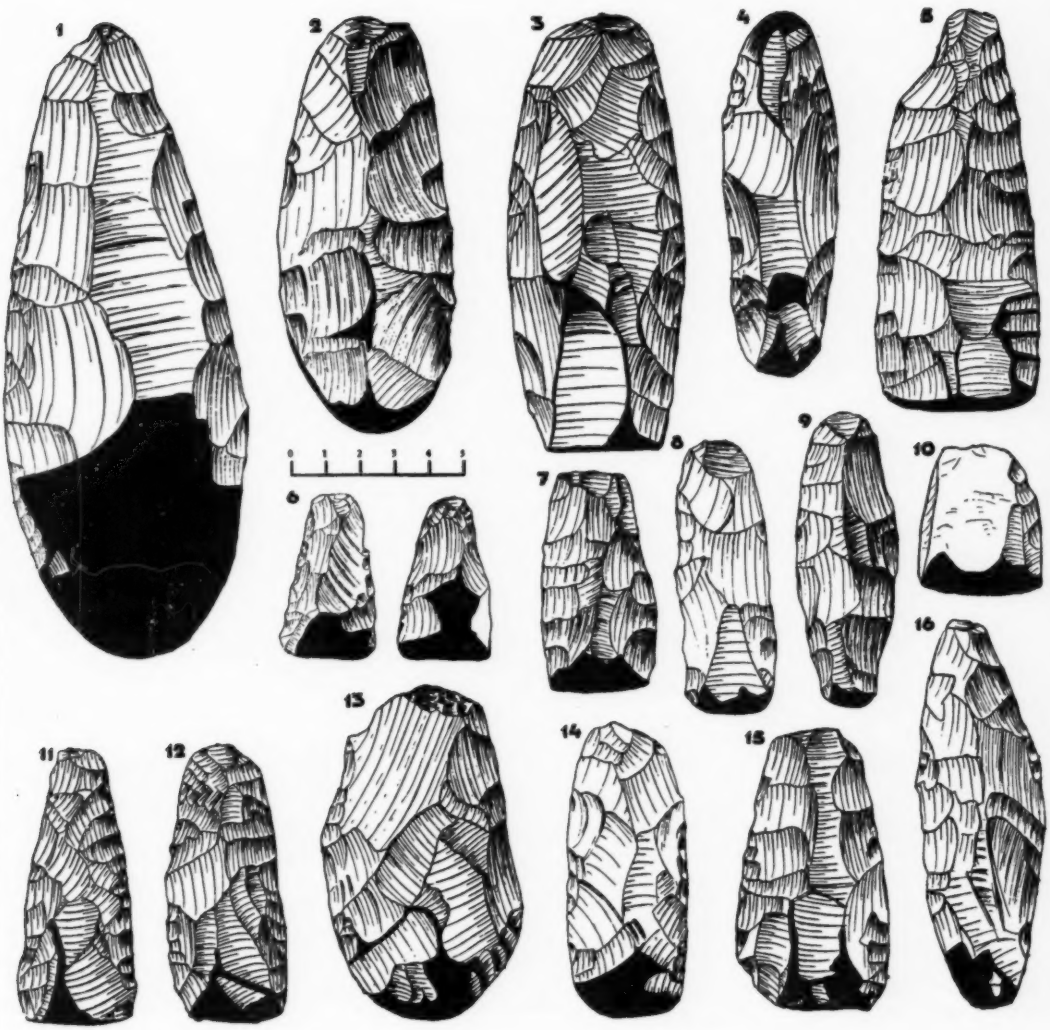


Figure 2. Axes, celts and hoes with polished cutting edge (in black)

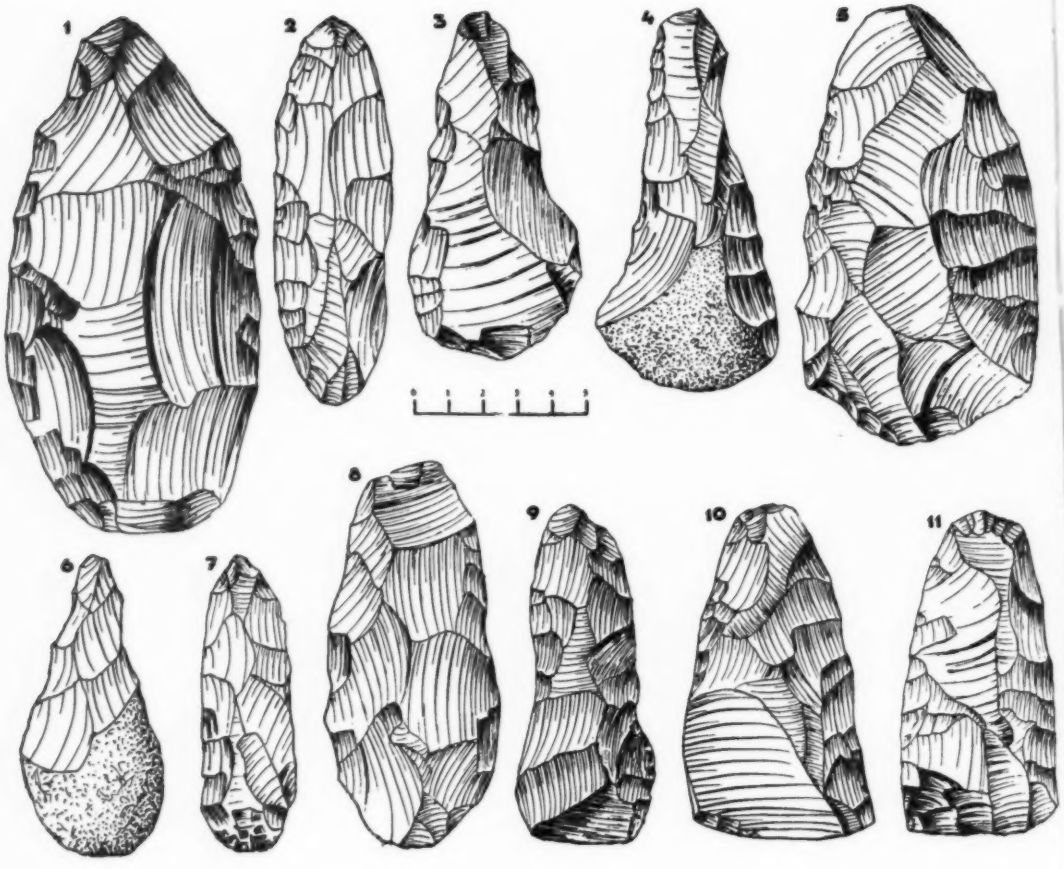


Figure 3. Axes, pick axes, hoes and tranchets

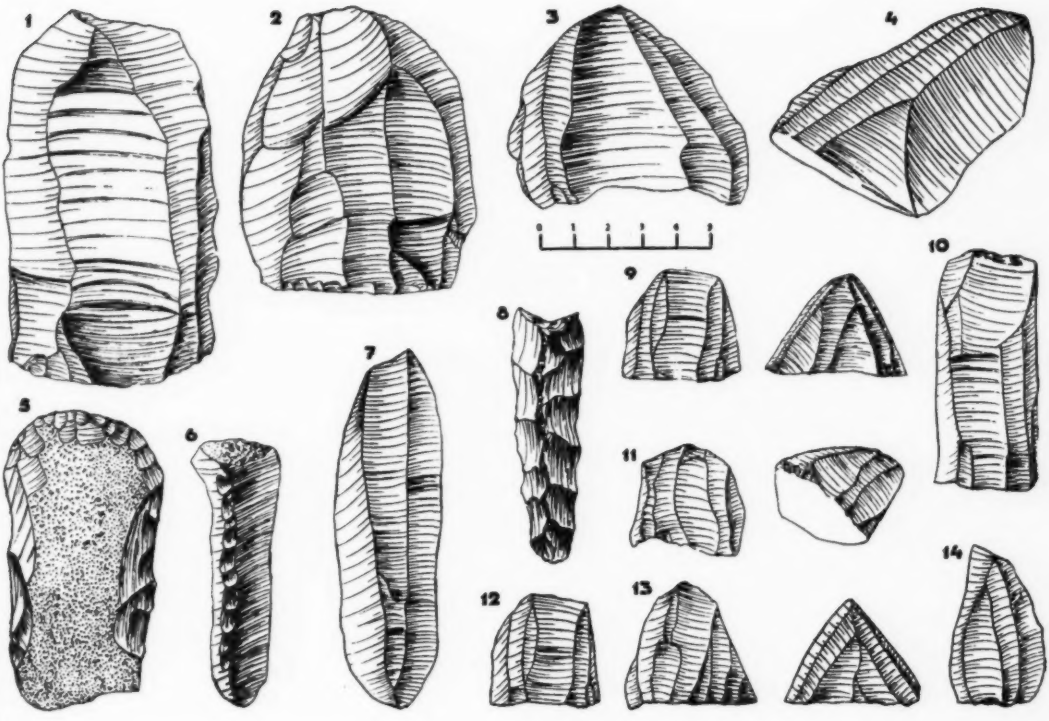


Figure 4. Flint cores, core trimming flakes and scrapers

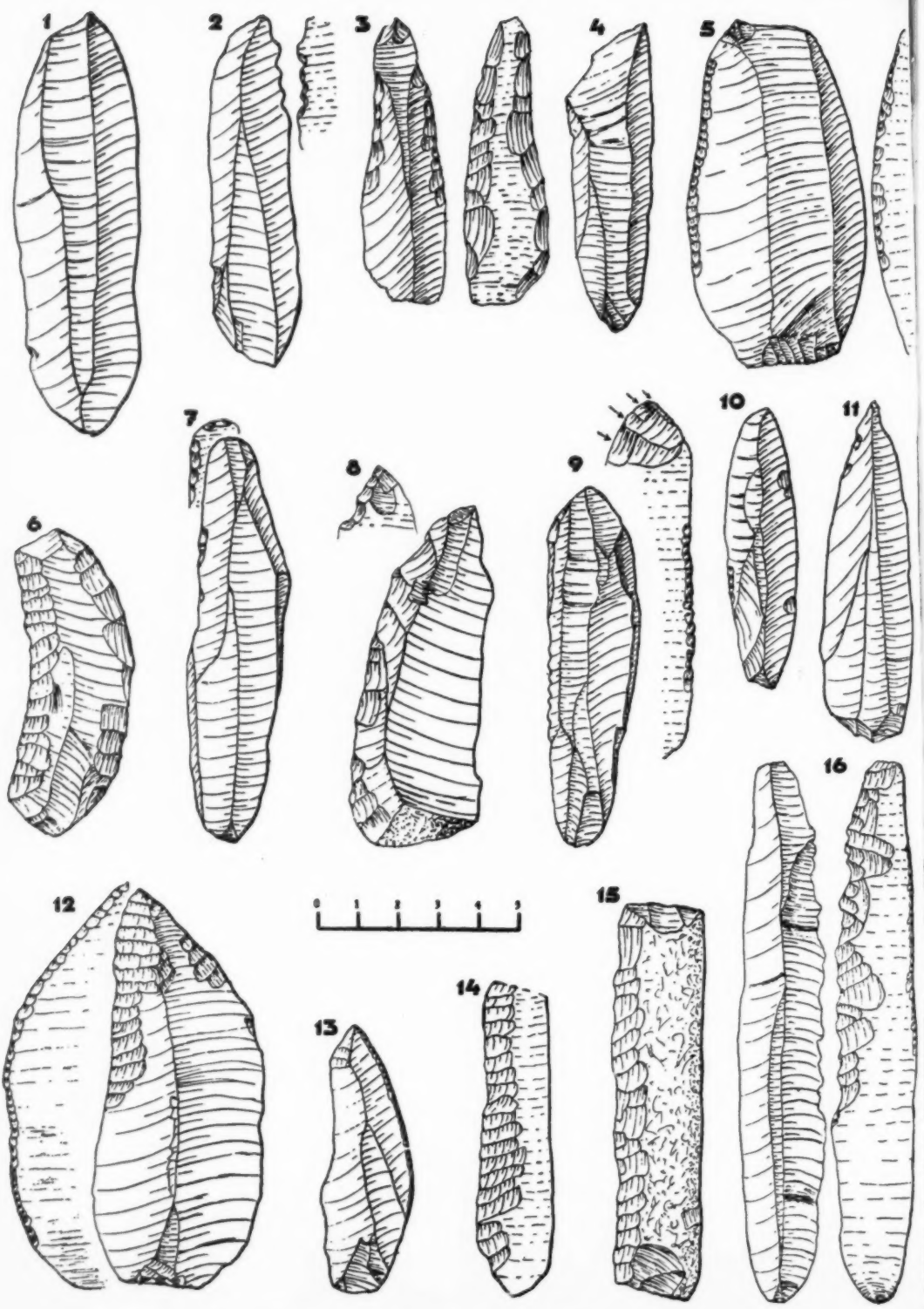


Figure 5. Blades, flakes, knives and scrapers

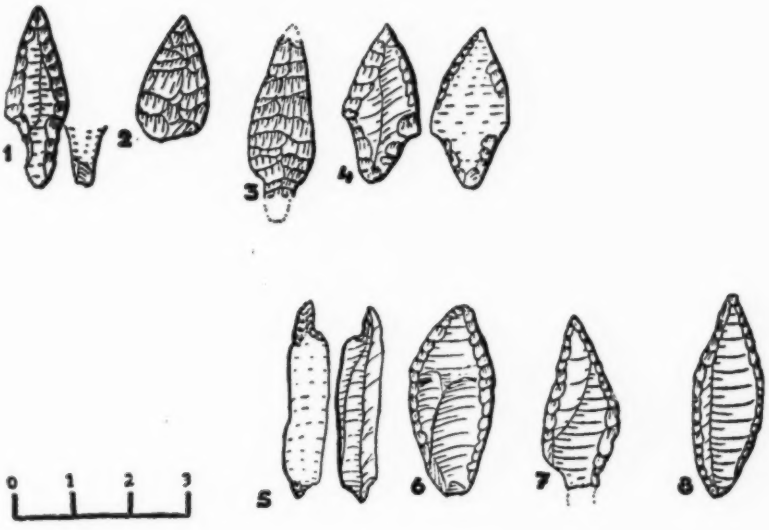


Figure 6. Arrow-heads and spear-heads

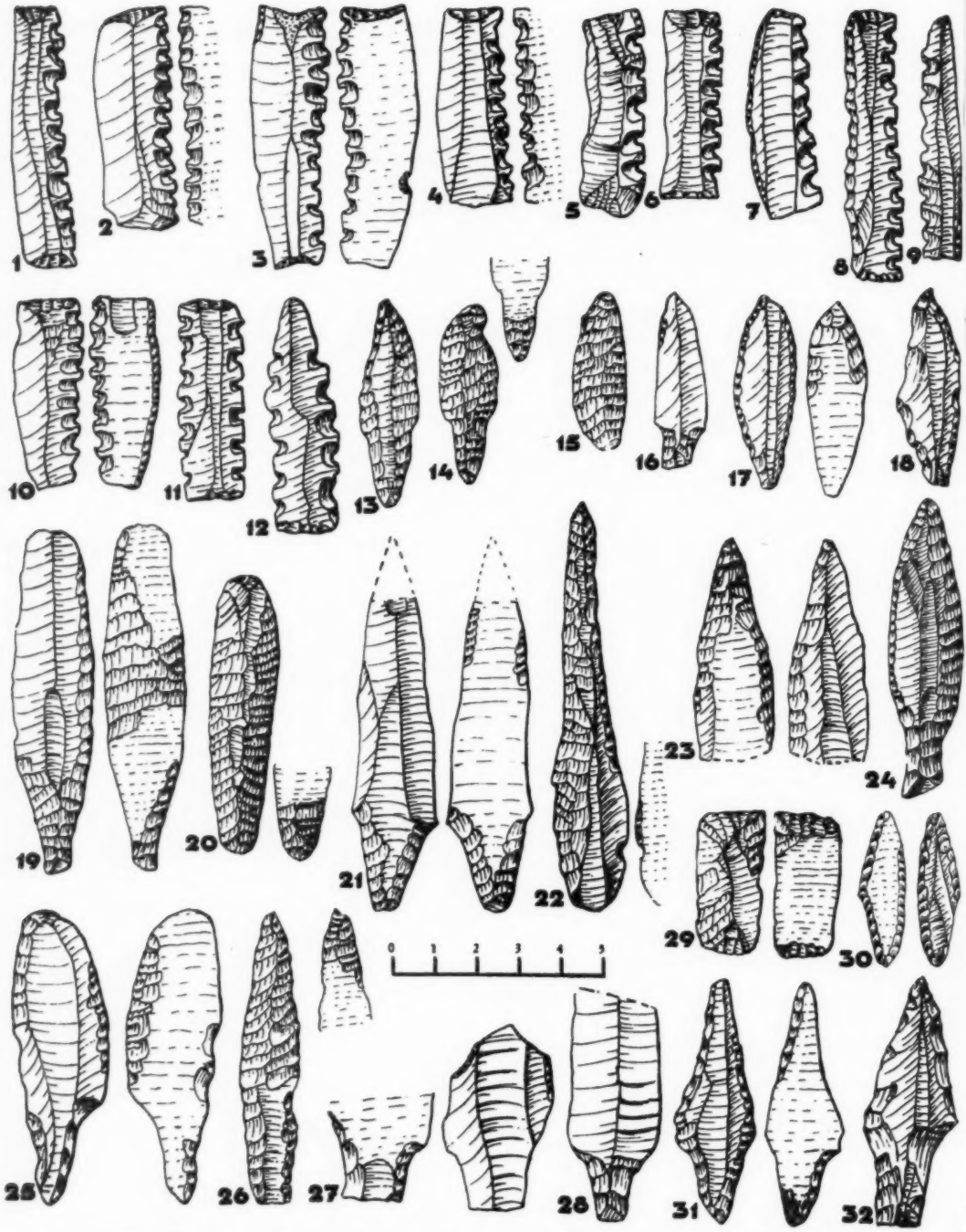


Figure 7. Arrow-heads, sickle-blades, tanged points, saws and serrated flakes

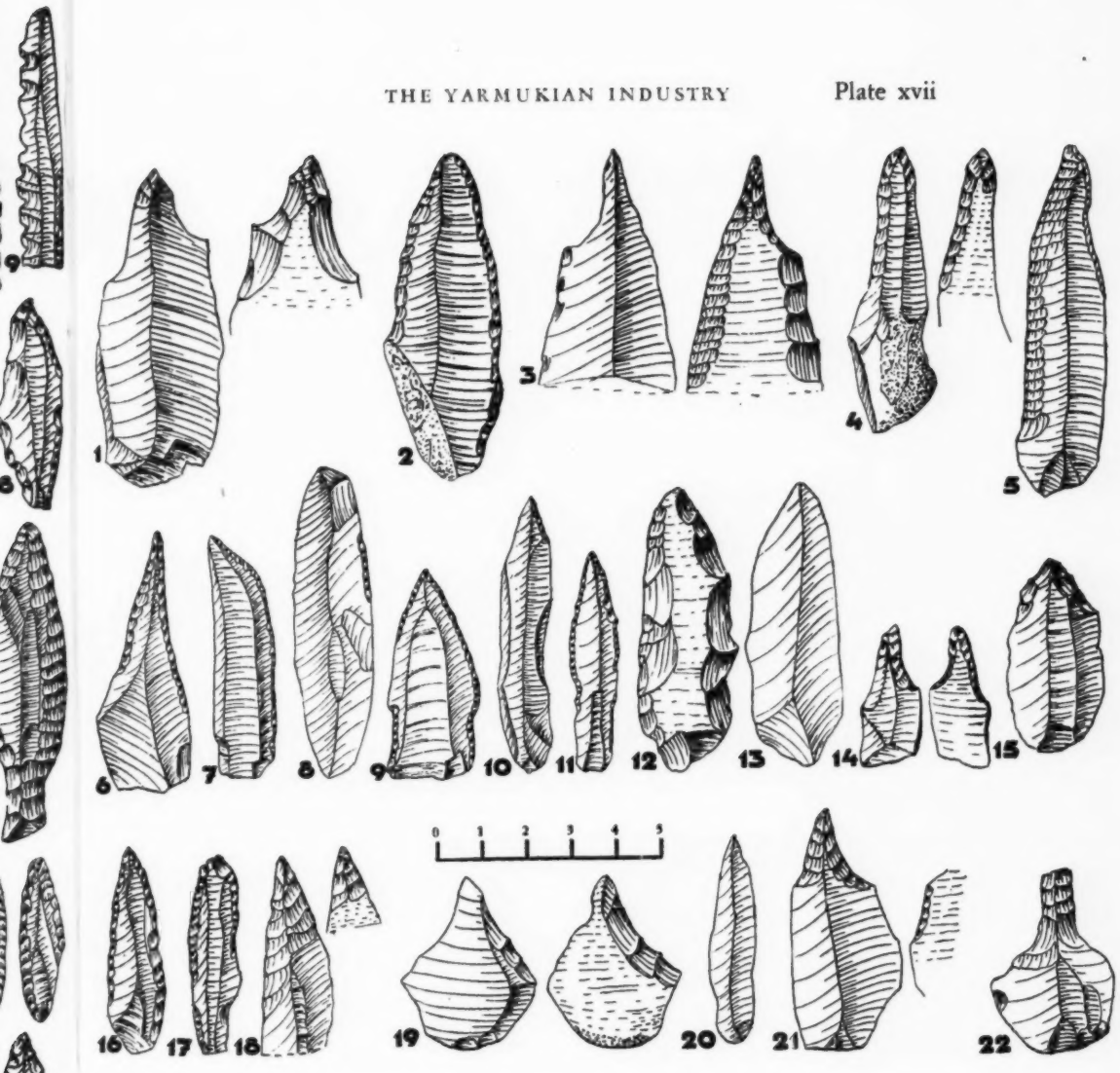


Figure 8. Awls

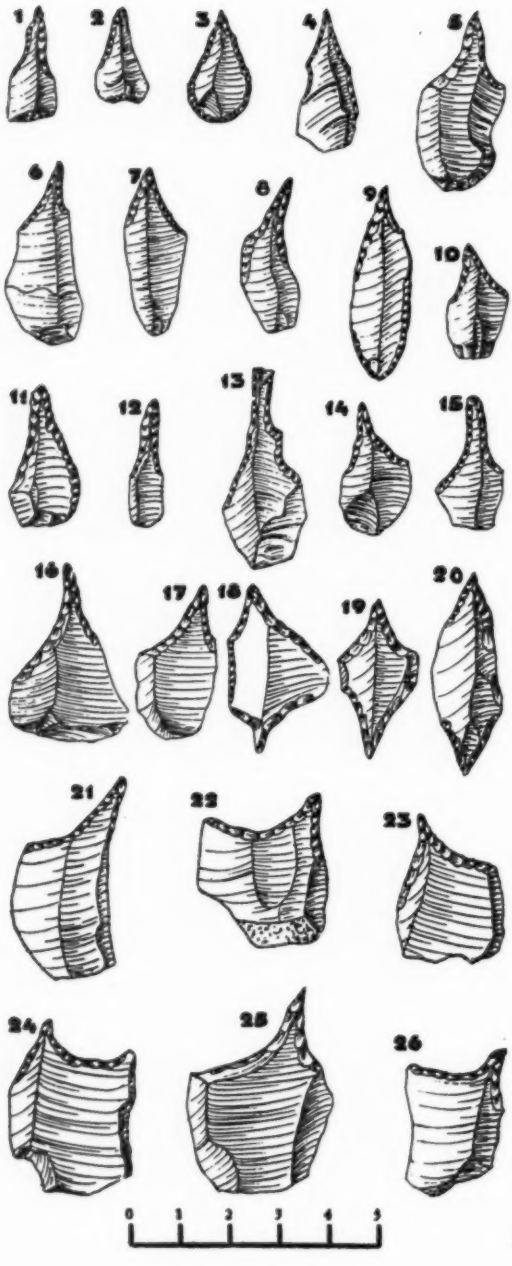


Figure 9. Pseudo-awls

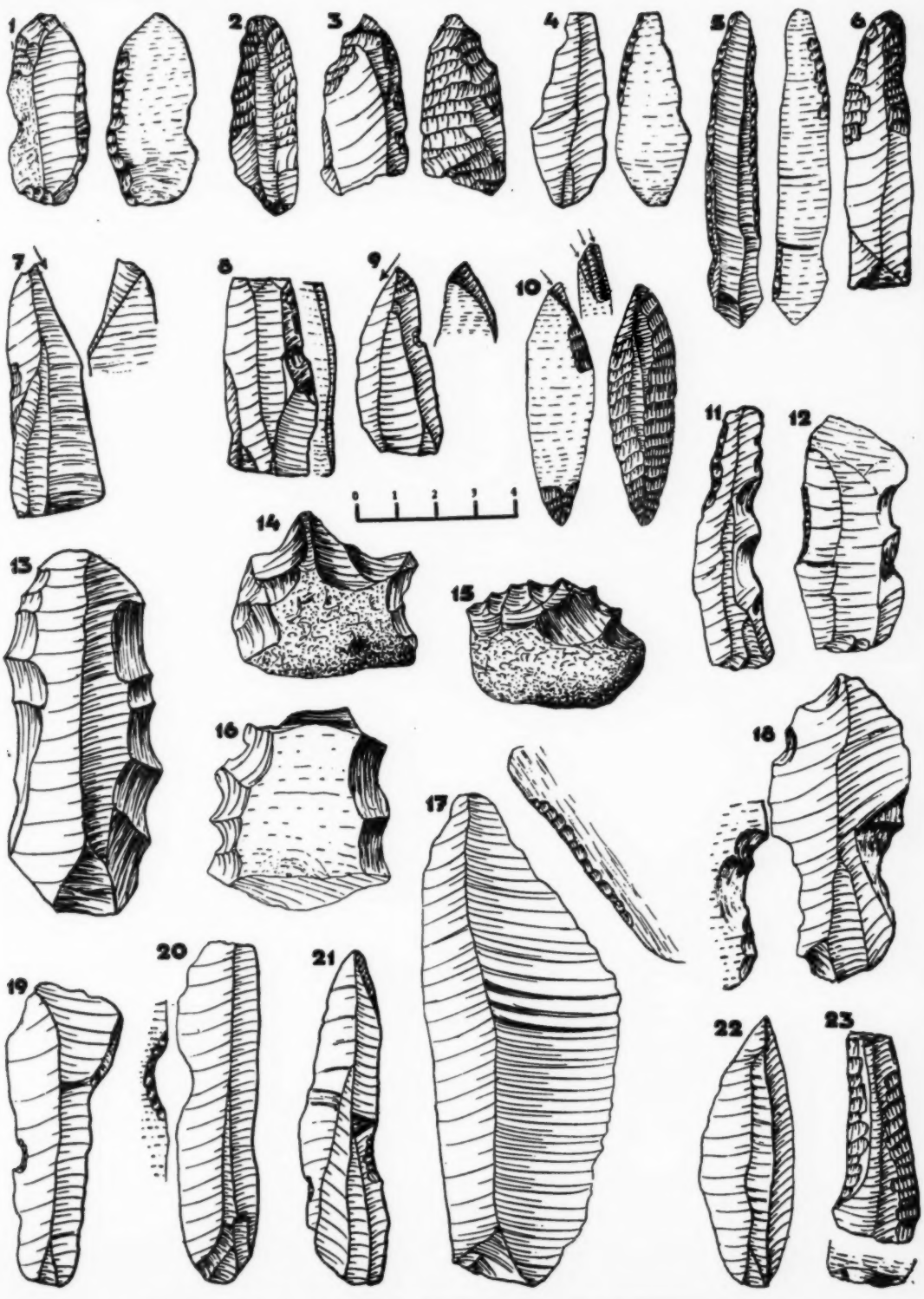


Figure 10. Gravers, serrated flakes and notched flakes

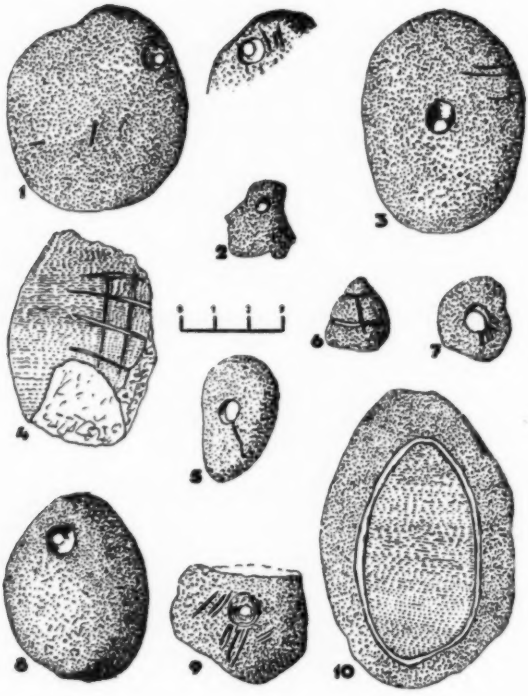


Figure 11. Stone pendants and cameos

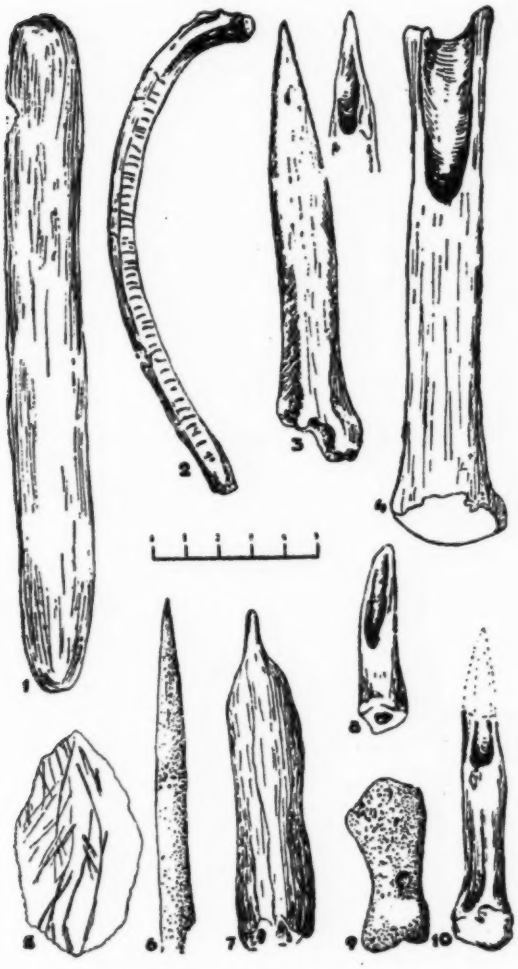
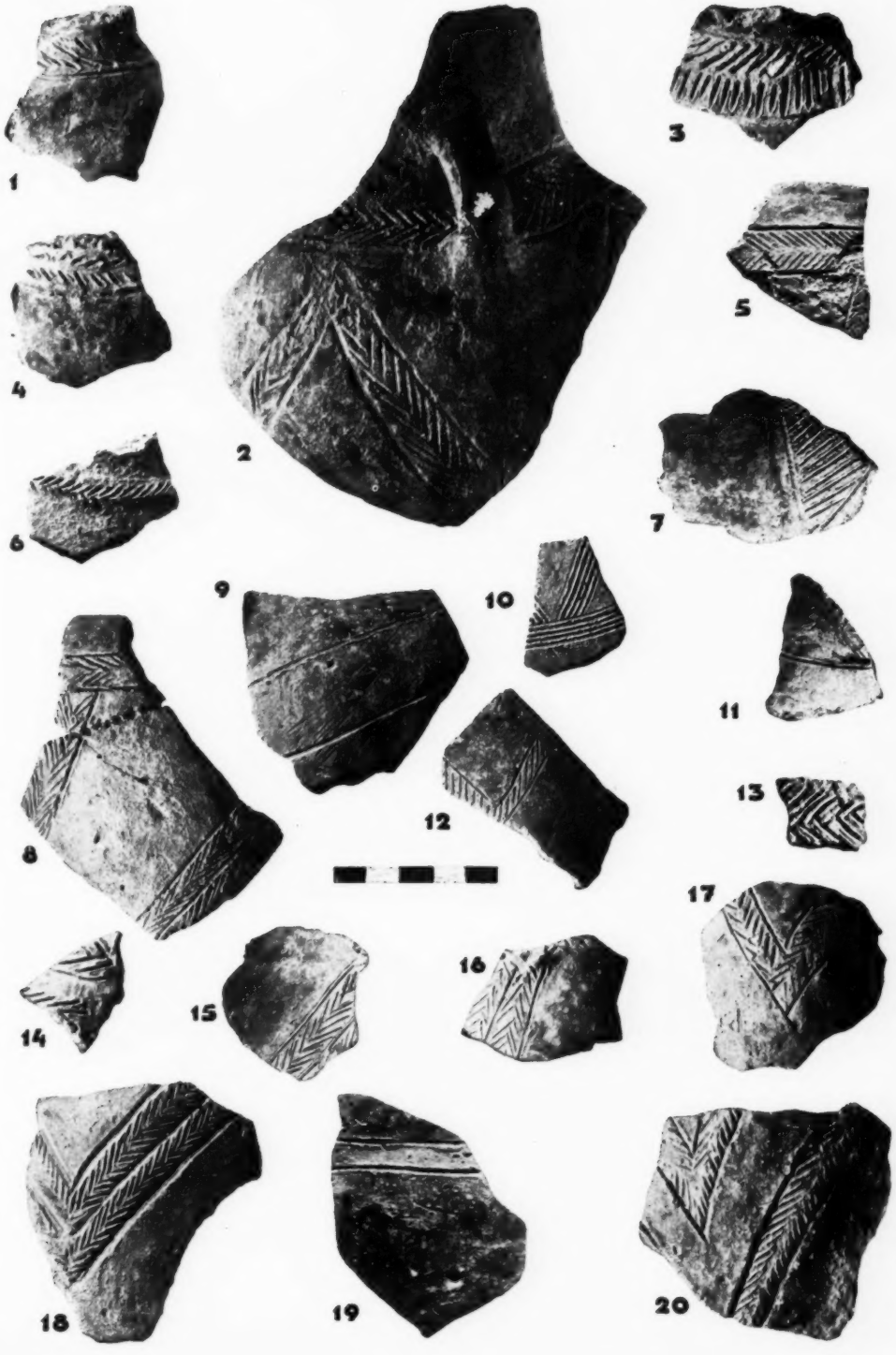
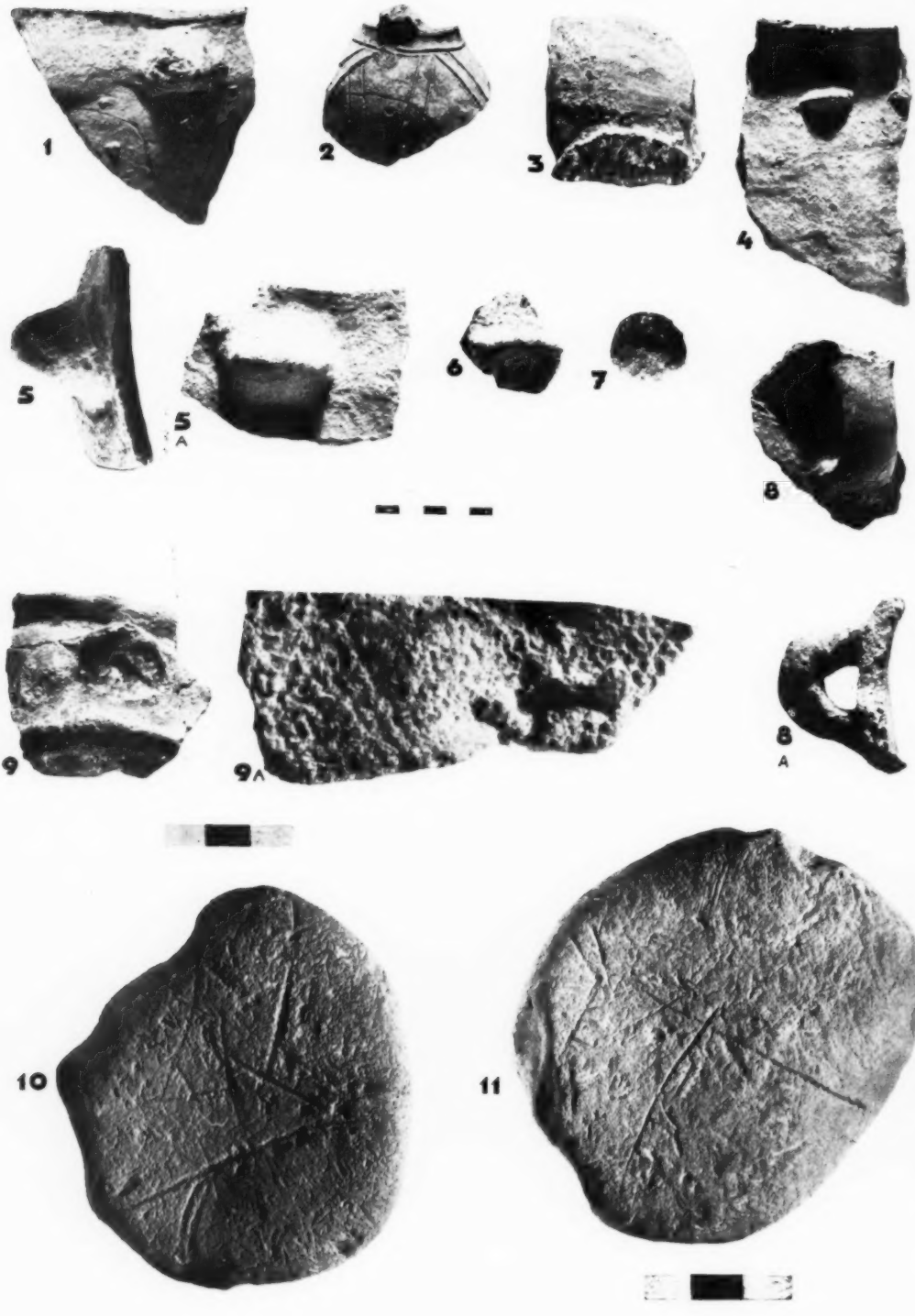


Figure 12. Bone objects

Figure 13. Pottery



Pl. i

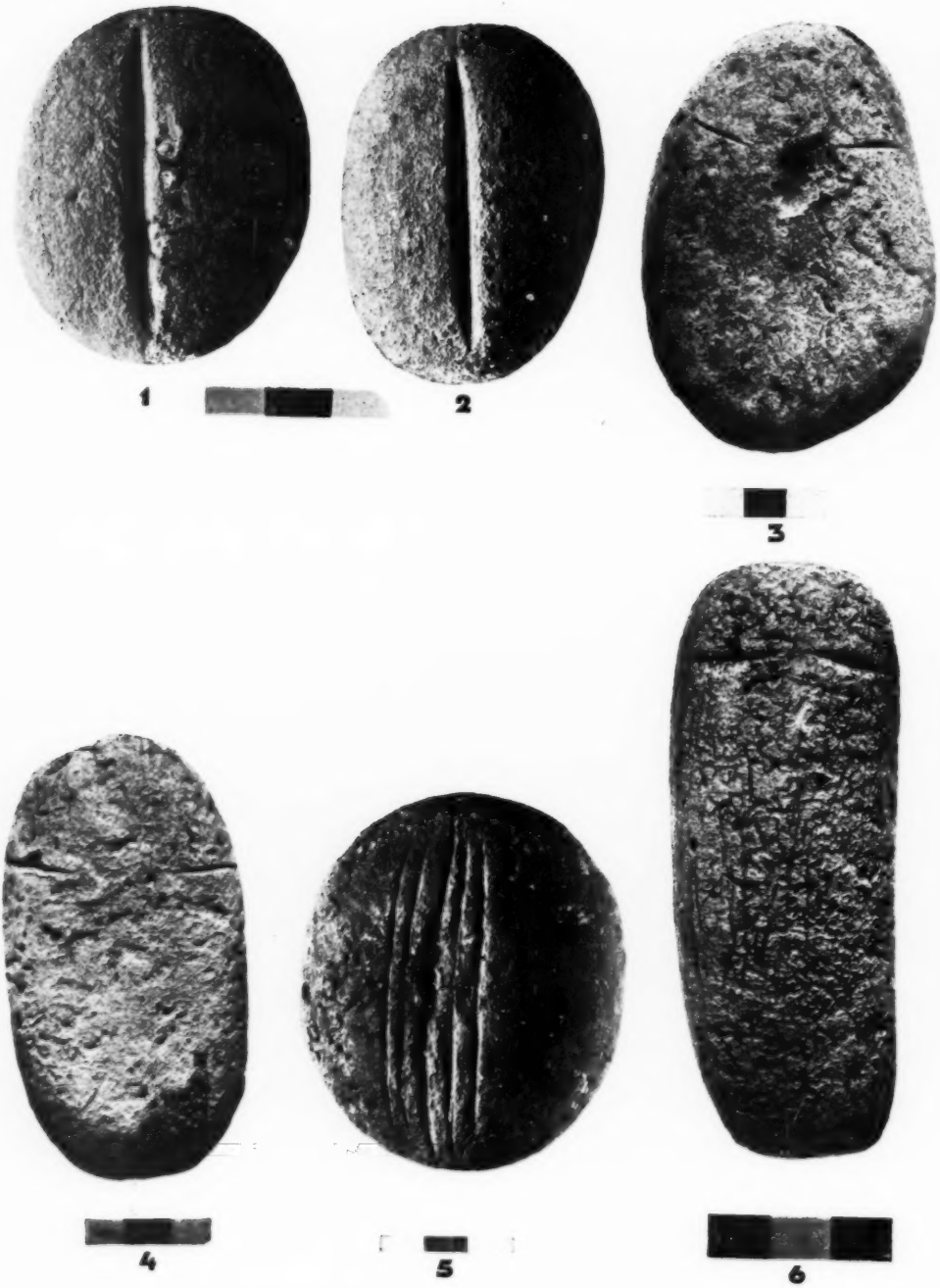


Pl. ii

Pl. iii

Pl. iv

Pl. v



Pl. vi

1 1A

2 2A

Pl. vii

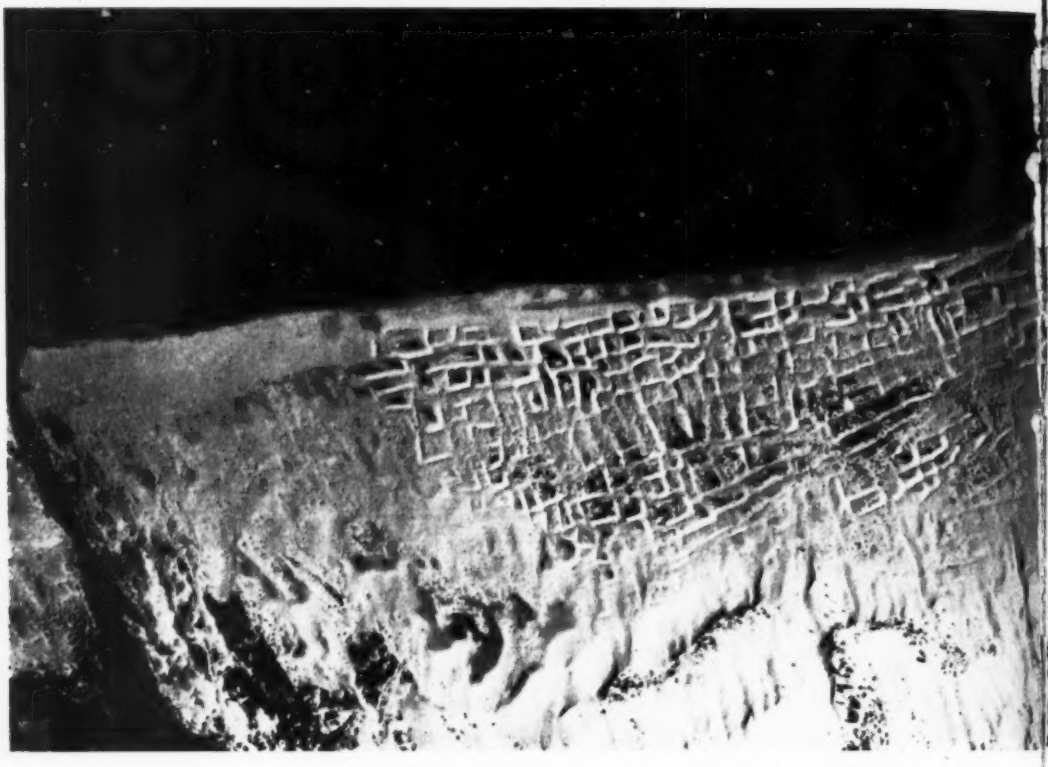


Fig. 1. AERIAL PHOTOGRAPH OF CAESAREA

Dune encroachment is shown by the sand covering up the ancient town with its 'insulae' to the left of the photo (South). The littoral current can be faintly detected near the mouth of the drained Mefjir River, the silt being transported from S to N along the Coast.

(Photo: Air Ministry, London, Crown Copyright reserved)

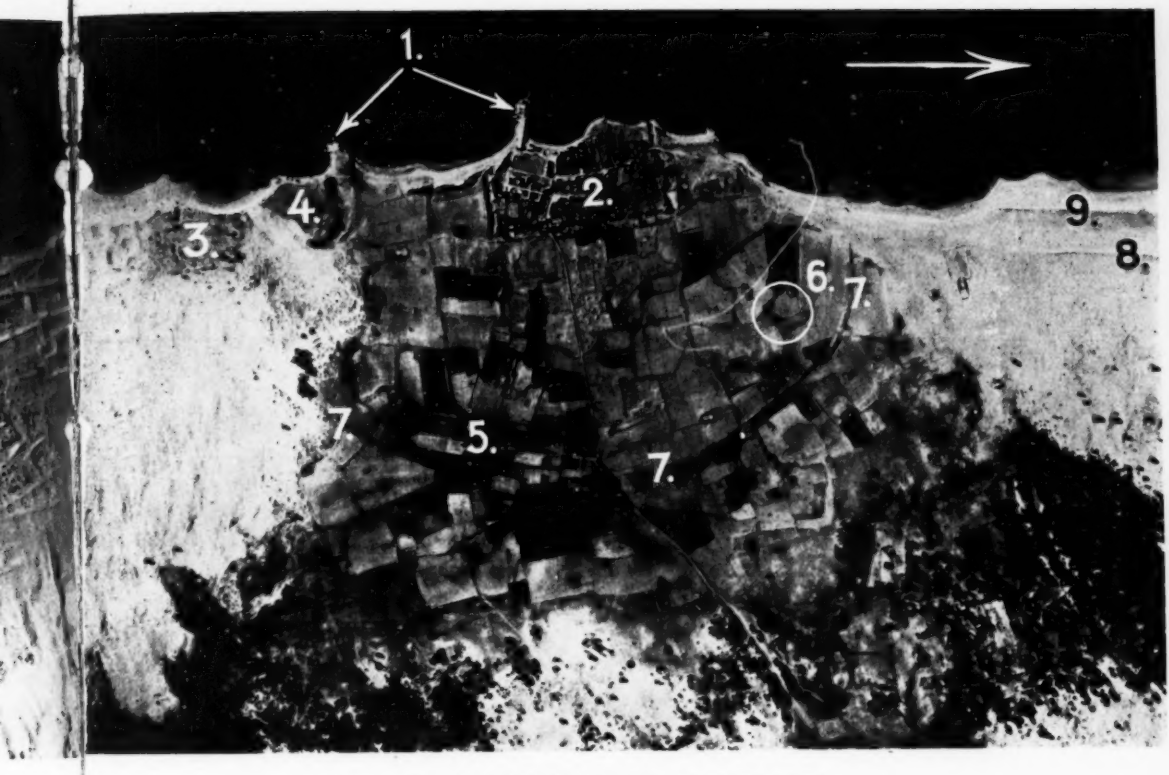


Fig. 1. AERIAL PHOTOGRAPH OF CAESAREA

1. The ancient moles constructed by Herod
2. The Crusader town
3. Modern Jewish settlement
4. Ancient theatre
5. Ancient hippodrome
6. Ancient amphitheatre, revealed by aerial photograph
7. Ancient Roman enceinte
8. Sanded up Low Level Aqueduct
9. Sanded up High Level Aqueduct, showing erosion to left (South)

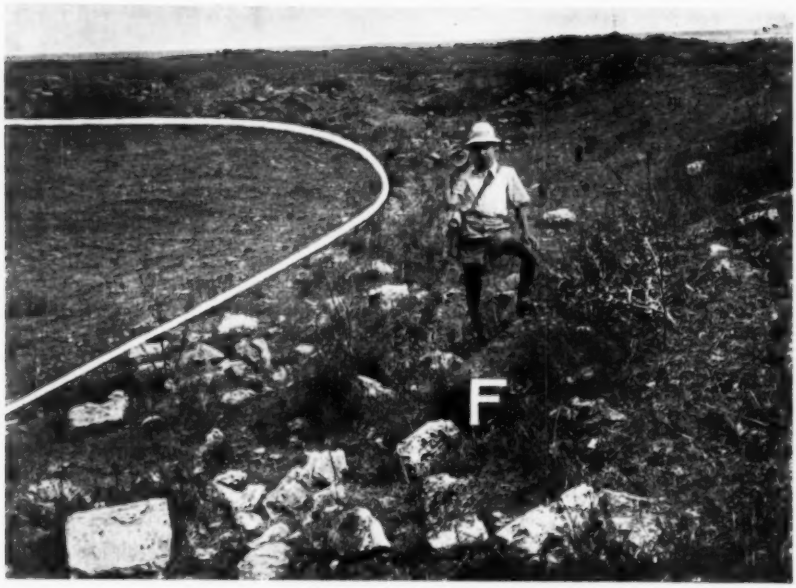


Fig. 2. THE AMPHITHEATRE

The amphitheatre mentioned by Josephus was only discovered with the help of the aerial photograph (6 on the aerial photo). This picture gives part of the arena with stone benches for the spectators (F) and the raised platform at the extreme right.

Fig. 3. THE HIGH LEVEL AQUEDUCT

Well preserved semicircular arches of the Roman aqueduct East of the swamp.

Fig. 4. REPAIRED ARCHES OF THE HIGH LEVEL AQUEDUCT
Where the aqueduct crosses the marsh a deviation was built (cf. Fig. 5). But even this did not help, the unstable soil causing a sinking of the arches. This photo shows supporting arches to prevent a sinking of the conduit-level. According to literary sources the repair was probably carried out in the sixth century.

Fig. 5. THE HIGH LEVEL AQUEDUCT

General view taken from the sandstone ridge where the aqueduct enters the tunneled hill. In the background the spurs of the Carmel, where the spring originates. To the right, part of the deviation mentioned in the former picture.

Fig. 6. THE ACTION OF THE SURF

In the foreground remains of the High Level Aqueduct, which suddenly breaks off about 500 m. north of Caesarea (in the background). The surf has eaten itself into the land eroding about 500,000 tons of soil and stone and destroying the aqueduct at the same time. Scattered pieces of the aqueduct can be seen lying on the ground of the beach in the direction of Caesarea.

Fig. 7. THE ROMAN DAM ACROSS THE ZERQA RIVER

This dam, with a causeway on top, caused the waters of the river to rise to such a height as was necessary to convey them to Caesarea. Openings in the dam allowed for the working of water mills.

Fig. 8. THE LOW LEVEL AQUEDUCT

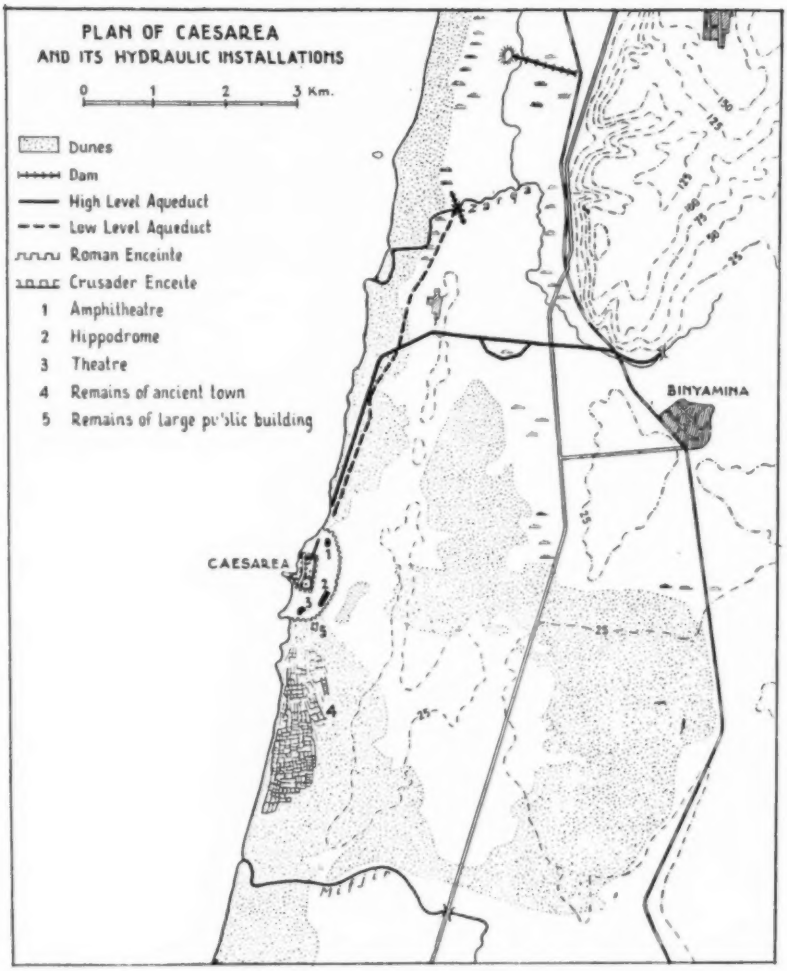
This aqueduct bringing water for agricultural purposes to Caesarea started as an open rock-cut channel. Later on (probably in early Arab times) it was partly covered with a vault in order to protect it against the encroaching sand dunes.

Fig. 9. GENERAL VIEW OF THE LOW LEVEL AQUEDUCT

This photograph shows the sanding up of the Low Level Aqueduct (No. 8 on the aerial photograph). The vault only of the channel which was once two metres high is still visible. In the background to the left the likewise sanded up High Level Aqueduct (No. 9 on the aerial photo), with its sudden break caused by surf-erosion. It will be seen that the sand has passed this 6 metres high obstacle.

Fig. 10. THE NORTHERN DAM BUILT ACROSS THE KABBARA SWAMP
This dam, built apparently in the third century connected the Carmel slopes with a knoll to the West (from which this photograph has been taken). It served to prevent the waters of the Zerqa River from spreading northwards after damming up the course of the river near its mouth. By thus raising the water level several metres it became possible to lead the water in the Low Level Aqueduct southwards to Caesarea.

Fig. 11. TOMBSTONE OF A JEWISH TECHNICIAN FROM CAESAREA
(cf. the article of M. Schwabe)


PLAN OF CAESAREA
AND ITS HYDRAULIC INSTALLATIONS
0 1 2 3 Km.
Dunes
Dam
High Level Aqueduct
Low Level Aqueduct
Roman Enceinte
Crusader Enceite
1 Amphitheatre
2 Hippodrome
3 Theatre
4 Remains of ancient town
5 Remains of large public building
CAESAREA
BINYAMINA

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